SCIENCE EDUCATION

WILLIAM CARLSTEAD VAN DEVENTER

VOLUME 52 APRIL, 1968 NUMBER 3

SCIENCE EDUCATION

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THE Sixty-First Science Education Recognition Award is made to Doctor William Carlstead Van Deventer, one of America's most distinguished science educators. Since 1953 he has been Professor of Biology and Head of the Department, Western Michigan University, Kalamazoo, Michigan.

Doctor William Carlstead Van Deventer was born October 22, 1908 in Salisbury, Chariton County, Missouri.

Ancestry—German-American:

Names of Parents: Father, A. D. Van Deventer, born 1877; Mother, Christine (Carlstead) Van Deventer, born 1878.

Paternal Grandparents: Presley Darns Van Deventer, born 1839; Elizabeth (Chowning) Van Deventer, born 1844.

Maternal Grandparents: Christian Carlstead, born 1835; Anna Mary (Klink) Carlstead, born 1839.

Paternal Great-Grandparents: John Van Deventer, born 1805; Harriet (Darns) Van Deventer; Thomas Chowning II, born 1809?; Jane (Sumner) Chowning born 1818?.

Maternal Great-Grandparents: ....; .... ; Gottlieb Klink; Jacobina (Ullrich) Klink.

Paternal Great-Great Grandparents: Isaac Van Deventer, born 1779; Ann (Mains) Van Deventer; ....; .... ; Thomas Chowning (I); .... ; Joseph Sumner, born 1774; Elizabeth Sumner, born 1784.

The Van Deventers descend from Jan van Deventer, who came to New Amsterdam from Utrecht, Netherlands, in 1662. Originally the family came from Deventer, as the "van" part of the name indicates, where it can be traced to the middle 1500's or earlier. Jan van Deventer settled in a portion of what is now the city of Brooklyn, where he was a minor official. His grandson, Isaac Van Deventer I, migrated to New Jersey. Thence, the family went to Bucks County, Pennsylvania, and finally to Loudon County, Virginia, where they arrived in 1771.

Isaac Van Deventer III, born 1779, built a home called "Locust Grove" on a farm near Leesburg, which was still occupied by a descendant of the family up to the time of World War II. His son John (born 1805) migrated overland to Florida (Monroe County), Missouri in 1835. John's son Presley, a Methodist (later Holiness) minister, moved to Salisbury, Chariton County, Missouri, in 1877. I was born in 1908, on the farm near Salisbury where he settled.

The Chownings came to Urbana, Virginia, from County Kent, England, in 1636. The name is Norman-French in origin, and can be traced in England back to the 1100's. My branch of the family moved west to Tennessee, and thence to Florida, Missouri in 1835. Thomas Chowning, my great-grandfather, was a physician, a graduate of what later became Vanderbilt University. His father also Thomas Chowning, was also a physician. There was a physician in each generation of the family back to the middle 1600's.

The Sumners came from Wales to North Carolina in the 1700's and thence west to Missouri, where they settled at Portage des Sioux, in St. Charles County, near St. Louis, before 1800.

The Carlsteads (originally Karlstadt) were Prussian. I know little about them, except that they settled in Randolph County, Missouri, about 1845. They were related to a military family in Prussia, but were apparently a younger branch of the family, who had no inheritance in Germany.

My maternal grandmother, Ann Mary (Anna Maria) Klink, came to Randolph County, Missouri from Nordlingen in Bavaria in 1857, as an eighteen-year-old girl. Her brother Phillip had come five years earlier. Nordlingen is a "fossil city," even now changed little since the Middle Ages. It has about 13,000 population, and is surrounded by a circular city wall that dates from the 1400's. It is the commercial center for a rich agricultural region called the Ries, still strip-farmed as in medieval times. The Ries is roughly circular, 12–15 miles in diameter. It is surrounded by a rim of low, eroded hills. It is said to be the remains of the crater of an ancient Jurassic volcano. It was first settled in Roman times, and the history of Nordlingen can be traced to the First Century A.D. It was the terminus of a Roman road, built by the Emperor Claudius.

Nordlingen was made a free city of the Holy Roman Empire in 1215. The high point of its history came in the 1630's when Gustavus Adolphus of Sweden quartered himself and his armies there, and lost the decisive battle of the Thirty Years War on the plain south of the city. It has played no major part in history since then, and fortunately escaped the bombing during World War II practically unscathed. Nearby Nuremburg was more than 60 percent destroyed.

Until I started to put this together I did not realize how much "research" was involved. Some of this material I have as a result of this last trip to Germany. Irene and I spent two days in Nordlingen. It is a most interesting place. I could have written several pages on it without exhausting the subject. The Van Deventer material came from a family history which was published a number of years ago, based on the researches of former Justice Willis Vandeventer who was one of Roosevelt's "Nine Old Men" on the Supreme Court. I talked with him in Washington just before World War II after he retired from the bench. He had traveled in Holland and South Africa. His hobby was the family. All members of it in America are descended from the same old man, Jan van Deventer, who came to New Amsterdam in 1662. The Chowning and Sumner family data is fragmentary. I have collected a little of it over the years.

Doctor Van Deventer married Irene Gibson at Maitland, Missouri, March 9, 1934.

Mrs. Van Deventer is of English and American pre-Revolutionary War descent. She was born and brought up on a farm in Holt County (Northwest) Missouri. She attended Central Methodist College at Fayette, Missouri, when I met her when we were both students.

Her father was a County Judge, and his grandfather, John Gibson, who migrated to that area from Yorkshire, England, in the early 1800's, was the first County Judge of Holt County. Her father's mother was named Nancy (Hanks) Gibson and was a distant cousin of the mother of Abraham Lincoln who had the same maiden name.

Mrs. Van Deventer's mother's parents were Kentuckians, who migrated to Northwest Missouri in 1869 following the Civil War. Her mother's father, Elijah Powell, after being mustered out of the Confederate Army, is said to have ridden with Jesse James in his early raids in Texas. The farm on which they settled bordered the unbroken prairie, and the bison and the camps of migrating Indians could be seen from the dwelling in the 1870's.

The Van Deventers are the parents of a son, Frank Gibson Van Deventer. Frank is a graduate of the University of Michigan Medical School. A psychiatrist, he is now serving as a Captain in the U.S. Army Medical Corps, stationed at Nuremburg, Germany. He married Sally Margaret Crow of Louisville, Kentucky, at Ann Arbor,

Michigan, June 20, 1959. They are the parents of two children: Matthew White Van Deventer, born in Detroit, Michigan, September 17, 1964 and Sarah Elizabeth Van Deventer, born in Nuremburg, Germany, December 4, 1967.

Education

Graduated Salisbury (Missouri) High School, June 1926, Valedictorian of class.

Graduated Central Methodist College, Fayette, Missouri, June, 1930. Majors: Biology and Chemistry; Minors: English, History, German.

Graduated University of Illinois, M.A., 1932, Major: Parasitology; Ph. D., 1935, Major: Field Zoology and Ecology; Minor: Plant Ecology.

Master's Thesis: "Lecithodendrium lampei, a New Species of Trematode, Parasitic in Bats."

Doctoral Dissertation: *Cambarus propinquus* Girard.

Post-doctoral work, in Science Education, Teachers College, Columbia University, 1945.

Teaching Experience

Assistant in Biology at Central College, 1928–1930 and at the University of Illinois, 1930–34; Biologist Monroe County Parks, New York, 1934–35; Summer Sessions at University of Missouri, 1939, 1940 and 1941.

St. Viator College, Bourbounais, Illinois, 1935–38, General Zoology, General Botany, Comparative Anatomy, Embryology, Ecology, and Genetics.

Stephens College, Columbia, Missouri, 1938–53, Basic Course in General Biology for non-majors, General Zoology, Embryology, Genetics, Outdoor Science, and Science and Religion.

Western Michigan University, 1953–present, Pre-service biology and junior high school science, graduate seminar in curriculum studies, graduate course in human ecology, help direct graduate program in science education (masters specialist's and doctors).

Non-teaching Experience

Conservation work, Monroe County Park Commission, Rochester, New York, 1934–35.

Farming in Chariton County, Missouri, until adult, then during various summers in the 1920's, 1930's, and 1940's.

Lectures, writing for newspapers, generally on biological subjects.

Organizations

American Association for Advancement of Science, American Institute of Biological Sciences, Ecological Society of America, National Association for Research in Science Teaching, National Science Teachers Association, National Association of Biology Teachers, Central Association of Science and Mathematics Teachers, Association for Science Education (British), Michigan Science Teachers Association, Agricultural History Society, British Agricultural History Society, Human Ecology Society, Federation for Unified Science Education.

Honors

President NARST, 1955–56, Vice-President NARST, 1954–55.

Human Ecology Committee, Ecological Society of America 1955–57.

Committee for Evaluation of General Education of the American Council on Education 1950–53. Chairman of Science Section of the above 1950.

Member and Chairman for many years of the College Committee of the National Association for Research in Science Teaching.

Member Midwest International Seminar for Regional Planning, Haslev, Denmark, 1949.

Head, Department of Biology, Western Michigan University, 1953–63.

Member Michigan Science Curriculum

Committee, State of Michigan, Department of Education, 1962–present.

Chairman of Subcommittee of MSCC (above) for the Development of Junior High School Science Materials.

Member Board of Directors, Michigan Science Teachers Association 1963–present.

Editor of *Michigan Science Teachers Bulletin,* 1963–present.

Listed in: Leaders in American Science, American Men of Science, Who's Who in America, Who's Who in American Education.

Publications

Some Influences of Man on Biotic Communities. *Proceedings of the Illinois State Academy of Science,* 1933.

A Winter Bird Community in Western New York. *Ecology,* 17:491–499, July, 1936.

Studies on the Biology of the Crayfish, *Cambarus propinquus* Girard. *Illinois Biological Monographs,* 15:198–316, August, 1937.

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The Course in General Zoology. Stephen College, 1940.

Science for Students in a Democracy. (with Philip N. Powers) Stephens College, 1941.

Course Outline for General Zoology. Stephen College, 1941.

Biology for You. Stephens College, 1942.

Course Outline for General Biology. Stephens College, 1944.

Man and His Environment. Stephens College, 1946.

Organization of a Basic Science Course. *Science Education,* 30:201–206, October, 1946.

Individualized Instruction in a Basic Science Course. *Science Education,* 30:269–273, December, 1946.

Service Course in Science Based on Human Problems. *Stephens College News Reporter,* 6:(5), February, 1947.

The General Biology Course at Stephens College. A chapter in *Science in General Education,* E. J. McGrath, editor. William C. Brown and Company, Dubuque, Iowa, 1948.

Report of Research Committee of the National Association for Research in Science Teaching on Junior College Science (W. C. Van Deventer, chairman). *Science Education,* 32:188–193, April, 1948.

Teaching Science in Relation to Religion. *Stephens College News Reporter,* 8:(6), March, 1949.

Trends and Problems in General Education College Science Courses (Report of the Research Committee of the National Association for Research in Science Teaching on Junior College Science (W. C. Van Deventer, chairman). *Science Education,* 33:183–190, April, 1949.

Teaching Science in Relation to Man's Thinking. *Science Education,* 35:104–106, March, 1951.

The Midwest Seminar: An Experiment in International Education. *Science Education,* 35:107–111, March, 1951.

The Growth of the Experimental Sciences, by James B. Conant. Review in *Science Education,* 35:112–114, March, 1951.

Science and Religion Course Culminates Five Year Study. *Stephens College News Reporter,* 11:(4), January, 1952.

Science and Man's Thinking. Stephens College, 1952.

Science Textbook Needs for the College Level. *The Science Teacher,* 20:71, March, 1953.

Laboratory Teaching in College Basic Science Courses. *Science Education,* 37:159–172, April, 1953.

A Cooperative Approach toward Evaluation of Science in General Education at the College Level. *Science Education,* 38:129–136, March, 1954.

Designing a Basic Science Course for a Specific College Situation. *School Science and Mathematics,* 55:91–103, February, 1955.

Questions Concerning Religion in Science Courses. A chapter in *Focus on Religion in Teacher Education.* American Association of Colleges for Teacher Education, Oneonta, New York, 1955.

The Teaching of Basic Premises as an Approach to Science in General Education. *Science Education,* 39:389–398, December, 1955.

The General Education Science Program at Western Michigan College (with Haym Kruglak and William J. Berry). *Science Education,* 40:98–102, March, 1956.

The Use of Subject Matter Principles and Generalizations in Teaching. *School Science and Mathematics,* 56:466–472, June, 1956.

Problems in Biology. Western Michigan University, 1956.

The Multi-Dimensional Science Course. Part I. *The Basic College Quarterly,* 2:(1) 25–29, Fall, 1956.

The Multi-Dimensional Science Course, Part II. *The Basic College Quarterly,* 2:(2) 25–30, Winter, 1957.

A Simplified Approach to Scientific Methodology. *School Science and Mathematics* 58:97–107, February, 1958.

Educational Values of Science in the News. *School Science and Mathematics,* 57:673–681, December, 1957.

The Field Trip as an Instrument of Teaching. *Metropolitan Detroit Science Review,* 19:28–31, December, 1958.

Implications of Recent Research in College Science Teaching. *School Science and Mathematics* 58:630–633, November, 1958.

Basic Ideas, Generalizations, and Subject Matter Principles Included in the Biological Science

Course (with staff). Western Michigan University, 1959.

Laboratory Experiences in Biological Science (with staff). Western Michigan University, 1959.

Readings in Biological Science (with staff). Western Michigan University, 1959.

Research in Teaching College Science. (with Vaden W. Miles) *College and University Bulletin* 11:(8), March 1, 1959.

A Rationale for the Teaching of Biology. *School Science and Mathematics,* 60: 113–121, February 1960. Included in *The Subjects in Curriculum, Selected Readings,* Frank L. Steeves, editor, The Odyssey Press, Inc. New York, 1968.

A Common Denominator for Scientific Problem Solving. *The Science Teacher,* 27:41–42, February, 1960.

Science for General Education in the Colleges (with Cyrus W. Barnes, Clement L. Henshaw, Chester A. Lawson, Abraham Raskin and Beth Schultz). Chapter VI in *Rethinking Science Education: Fifty-Ninth Yearbook of the National Society for the Study of Education,* 1960.

Needed Research in Science Education. *Science Education,* 44:40–44, February, 1960.

The Basic Science Courses at Western Michigan University. Chapter XXI in *Science in General Education,* R. R. Haun, editor, William C. Brown and Company, Dubuque, Iowa, 1960.

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An Aquatic Biology Unit for Ninth Grade Biology (with Inez P. Sutton and Beth Schultz). *School Science and Mathematics,* 62:315, 329, March, 1962.

Human Ecology. Western Michigan University, 1962. Revised 1967).

BSCS Biology. *School Science and Mathematics,* 63:89–94, February, 1963.

Laboratory Centered Science Teaching. *Metropolitan Detroit Science Review,* 24:105–107, September, 1963.

Aldrovandi on Chickens: The Ornithology of Ulissee Aldrovandi (1600). Translated from the Latin by L. R. Lind. Review in *Agricultural History,* 38:56–58, January, 1964.

Land Use Policy and Problems in the United States, Howard W. Ottoson, editor. Review in *Agricultural History,* 38:59–60, January, 1964.

The Teaching of Science at the College and University Level. Chapter VII in *Review of Educational Research: The Natural Sciences and Mathematics.* Reviews of Literature 1960–1963, 34:334–346. American Educational Research Association, June, 1964.

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New Horizons in Curriculum Development. *Newsletter of the Michigan Science Teachers Association,* 13:(3) 11–18, February, 1966.

Toward a "Comparative Anatomy" of the Curriculum Studies. *Science Education,* 50:(3) 196–203, April, 1966.

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New Developments in the Sciences for Elementary and Secondary Schools. *Michigan School Board Journal,* 13:(5) 12–13 and 22–23, July, 1966.

The Changing Mile, James Rodney Hastings, and Raymond N. Turner. Review in *Agricultural History,* 41:100–101, January 1967.

After the Curriculum Studies, What? *FUSE Bulletin,* Number 5, July, 1967.

Native Inheritance: The Story of Corn in America, Howard T. Walden II, and *The History and Origin of Maize,* Major M. Goodman. Review in *Agricultural History* 41:322–323, July, 1967.

Michigan Project for Junior High School Science. *The Science Teacher,* 34:30–31, December, 1967.

Professor Van Deventer began as an invertebrate zoologist but since leaving graduate school has successively worked in ecological ornithology and science education. He says that in this last field he is largely self-trained. Being one of the very top individuals in the science education field, the lack of formal courses in science education raises some questions as to the actual value of such courses. At least some personal characteristics may offset such advantages as these courses may have—enthusiasm, an excellent background in science, wide and analyzing reading in science education, a kind of an intuitiveness in sensing significant problems, the ability to separate the important problems from the less important.

These Dr. Van Deventer (as well as a number of other noted science educators) have possessed. He has been successively interested in general education science, the preparation of high school biology teachers (using BSCS materials principally), and research in the development of curriculum materials for junior high school science. Other investigations and writings have been on the utilization of science-in-the-news, the nature of scientific problem-solving, and the role of principles and generalizations in science teaching at the general education level.

Dr. Van Deventer's philosophy, beliefs and practices in the field of science education constitute his major contributions as a science educator. Listed below, they can be found in many of his publications listed above:

1. The K-14 spectrum constitutes the legitimate area for general education. All science, K-14, is *general science,* even though for teaching purposes, it may be dealt with in separate subject-matter divisions.

2. The most worthwhile and productive goals for science teaching in the K-14 spectrum are *ideas and understandings.* Facts and skills constitute tools for getting at ideas and not ends in themselves.

3. We may recognize a hierarchy or gradient of generalizations (principles, ideas, understandings) on the basis of their relative breadth, ranging from (1) "subject matter principles" of the Martin-Washton-Blanchet type, which rest directly on the facts of science, through (2) "area principles" of the type of the BCSC themes (either like these limited to one field, or cutting across two or more fields), to (3) the "basic assumptions" and behaviors that characterize all science (objectivity, tentativeness, consistency, causality, uniformitarianism, relativeness, intergradation, and others). These all constitute legitimate goals for general education science teaching.

4. For teaching to be meaningful it must be directed toward some goal. All materials used, all methods, all laboratory experiences, demonstrations, lectures, readings, audio-visual presentations, or anything else must be selected to help students toward the chosen goal. Otherwise these activities are meaningless, and probably are a waste of time. Teaching which is not goal-directed is probably not teaching. Cataloging is not teaching. Surveying is not teaching.

5. Scientific problem-solving does not differ basically from layman's problem-solving. It consists of the same elements: (1) Setting up a tentative solution on the basis of the best evidence that is available; (2) trying out this solution in relation to new data; (3) if it works, continue to use it; (4) if it does not work, return to the starting point, and try out a new or modified tentative solution, using new data as it accumulates. (5) Continue this procedure until a workable solution is found, or a realization is reached that no solution is possible.

6. Although the term "laboratory" is used to include experiences of purely illustrative nature, true laboratory may be equated with problem-solving. In this sense, laboratory is not defined or limited in terms of a place, a room of special type, equipment, a special time, or particular subject matter. It can and does take place anywhere and anytime that problems, real and meaningful to the student, are being attacked or solved. This may be in a special room, using special equipment, at a special time; or it may be in the field, in the library, or other place of study. *Laboratory is problem-solving; problem-solving is laboratory.* It follows that in teaching situations, much that we have not thought of as laboratory, is laboratory; and much that we have called laboratory is not laboratory.

7. In pursuing a problem the student should be accorded the "right to be wrong," to arrive at a wrong answer, while searching for a right one. Mistaken conclusions can be corrected; but faulty methods, once learned, are difficult to eradicate, and for the student to be told the correct answer is no method at all.

8. There has been much discussion of "subject-matter-centered teaching" versus "student-centered teaching." Having come up through and experimented with both of these, I find that I am now concerned with "idea-centered teaching."

9. All of the modern curriculum studies list "inquiry" as a goal or a method of achieving a goal in science teaching, yet it is difficult to find agreement on a definition of inquiry. I believe that inquiry consists of *inquiring: asking questions,* the teacher asking questions of students, students, asking questions of the teacher and of one another. I believe, however, that these questions should be asked at all levels along a gradient from those which are easy to answer to those which are impossible (at present) for anyone to answer. Only by such a procedure can we give to students a feeling of being on the frontier of the advance of science.

Travel

Travel includes much of the United States, Canada, England, Scotland, Ireland, Germany, Netherlands, Sweden, Norway, Denmark, and Germany. Much of the travel has been done with friends. Both Dr. and Mrs. Van Deventer enjoy travel and hope to do much more in the future. In their travels, Dr. Van Deventer has been interested especially in agricultural practices. This ties in with his earlier boyhood

farm experiences and his later interest in agricultural history and human ecology. Mrs. Van Deventer and her sister still own the family farm in Missouri which the Van Deventer's visit regularly.

Dr. Van Deventer is a member of the vestry of St. Martin's Episcopal Church, Westwood, Kalamazoo, Michigan. He teaches a Sunday Class of sixth and seventh grade children, "hoping to give them a working knowledge of the Bible and biblical history, which, unfortunately, children no longer get in school, in spite of the fact that these constitute one of the foundation pillars of our culture. . . . I like working with young people. I have done teaching and counseling (formal and informal) for the past 41 years."

Doctor Van Deventer has many hobbies but they do not include bridge, golf, fishing, or hunting. Gardening in his nine-tenths of an acre in suburban Kalamazoo is a major hobby except in the winter months. He grows several varieties of strawberries, red and black raspberries, blackberries, gooseberries, red currants, rhubarb, asparagus—"all because I like to eat them. I grow, select and hand-fertilize and hybridize about 30 varieties of colored Indian maize: red, green, blue, white, pink, black, purple, brown, and various mixtures. We use these for autumn decoration and give some to our friends. I have a ten-year-old black and white-spotted tom cat named "Twenty-Six Mice" who is my constant companion and helper in the garden. He watches imaginary creatures called "wobblies" off me while I work. He is not spoiled, but is highly personalized."

In response to our less-than-serious suggestion that he was a noted Missouri "hog-caller," Van says:

> I am sorry to have to tell you that I was never a "hog caller." My father was quite expert at it, but I could never make the hogs hear me more than 100 yards away, and even then they paid no attention to me! When we would be taking a bunch of hogs across a pasture or through a gate, Dad would go ahead of them and call them. I thought it rather ineffectual at the time and told him that all he did was "'hollow" at them. I followed behind them and did the real work, driving them! My public speaking training took place in college. I had quite a bit of it because I played with the idea of law, the ministry, and journalism for awhile as an undergraduate.

Van has been quite well known as raconteur of many delightful Missouri stories. Before and after (and sometimes during) Executive Committee meetings of NARST, Van often delighted the members with these stories. Van has quite a repertoire of these stories. Here is his recent comment regarding these stories.

> The Missouri stories have not been neglected. I am sure my classes get quite bored with them, and they are foreign in this part of the world. I think I told you once that I never considered myself as good a story teller as you thought I was. I had an uncle, my father's brother, who inherited $1,000 from the estate of an old friend, for "the stories he told." He was my fox hunting, whiskey drinking, corn cob pipe smoking uncle.

Van has been, for many years, a prolific reader of science fiction stories. He includes a lecture on the use of science-fiction stories in one of his science teacher classes. Could one say that, in a sense, the wide-spread reading of science-fiction stories has replaced the earlier very popular with teenagers Horatio Alger series?

The Van Deventers reside at
3629 Canterbury Avenue
Kalamazoo, Michigan 49007

Possibly we have been remiss in not putting a greater emphasis upon the contributions the wife has made to the success of their husband. This is true in the case of the Van Deventers. A frequent visitor to the NARST meetings, Irene made tangible contributions to the social side of the meetings.

Doctor Van Deventer as twenty-third president of the National Association for Research in Science Teaching presided at the twenty-ninth annual meeting held in Chicago, April 21–23, 1956. The previous year he had served as vice-president of NARST. Never a "pusher" or one "to-throw-his-weight around," Dr. Van Deven-

ter's service of four years on the Executive Committee of NARST was marked by smooth, quiet effectiveness.

As a professional science educator and researcher in science teaching, Dr. Van Deventer ranks high among his peers, certainly near the top or possibly at the top of present-day contributors. Many of his sixty-six publications are among the very best research papers that have been published relating to American Science Education. Presently the writer considers one of Dr. Van Deventer's really significant contributions to the advancement of science teaching in America is his serving as Editor of the *Michigan Science Teachers Bulletin* (1963–present). This *Bulletin* is really a very fine publication and undoubtedly making not only a significant contribution to science teaching in Michigan, but outlying states as well.

Professionally and personally Van is the kind of a man whom one would like to roam all over God's Green Heaven *Farther Along*. Need more, could more be said! As Ralph Waldo Emerson said in *We Are Never Old*

> Spring still makes spring in the mind
> When sixty-years are told.

So to Doctor William Carlstead Van Deventer, noted promoter of science education research, is proudly made the Sixty-First Science Education Recognition Award.

CLARENCE M. PRUITT

MERVIN ELIJAH OAKES

1892–1968

IT was a real personal shock when we learned of the passing of Doctor Mervin E. Oakes on February 19, 1968, in a Danbury Hospital from a coronary thrombosis. Our aquaintance with Dr. and Mrs. Oakes dates back to the late twenties when we were classmates working on our doctorate degrees at Teachers College, Columbia University. This warm friendship for Mervin and Mrs. Oakes continued through the passing years. Renewal of acquaintance at professional meetings and through rather extensive correspondence over the years has been one of the real joys of our personal and professional life. The passing of Dr. Oakes is a great loss to the cause of science education, to the teaching profession in general, and a host of personal friends.

We wish to quote three articles published in the *Brookfield Journal,* Brookfield, Connecticut, February 29, 1968, including the fine tribute paid Dr. Oakes by Nancy Hagmayer:

A teacher of biology, science and English over a period of 50 years, Mervin E. Oakes, 76, suffered a fatal heart attack Monday night, Feb. 19, after being admitted to Danbury Hospital the previous day.

Mr. Oakes, of Pocono Ridge Road, moved to Brookfield following his retirement five years ago as a science teacher at Queens College in Long Island.

His association with the college began when it was founded in 1937.

A native of Lecompton, Kan., he was the son of a Methodist minister, the Rev. Isaac Oakes. His mother was the former Alice Stone.

He received an A.B. degree from the University of Southern California following graduation from Colton High School, also in Calif. His M.A. and Ph.D. degrees were obtained from Columbia University in New York.

Mr. Oakes was the author of several educational and scientific publications. He taught at Teachers College of Columbia University and in 1931 became Head of the Science Department at New York State Normal School, Fredonia, New York.

He taught general biology and comparative anatomy at Washington Square College of New York University from 1923 to 1928 when he was an assistant, and later instructor in the Department of Natural Sciences at Teachers College, Columbia University.

Mr. Oakes was an avid dahlia grower on his five-acre home site. He was interested in Indian relics, photography, stamp collecting, books and pictures of covered bridges.

At the time of his death he was serving as a member of a committee here to plan proposed Still River parkway along the Route 7 expressway.

He was active in many organizations including the Candlewood Camera Club, Danbury Mineralogical Society, Gentlemen's Club, the Harlem Valley Men's Garden Club of Brewster, N.Y., and the Brookfield Conservation Commission.

Besides his wife, the former Grace Thorne, he leaves a son, Mervin Oakes of Norwood, N.J., two grandsons, James and Donald Oakes and a granddaughter, Miss Nancy Oakes, two sisters, Mrs. Howard Butterfield of Balboa Island, Calif., and Mrs. Maude Bolandri of San Francisco and several nieces and nephews.

Funeral services were conducted from the Brookfield Funeral Home, Route 7, Thursday morning, Feb. 22 with the Rev. Robert A. Hybel officiating.

Interment followed in the Reformed Church Cemetery at Tappan, N.Y.

AN APPRECIATION

The Brookfield Journal on Feb. 21 announced the death of Mervin Oakes. His biography appears today.

But in the Feb. 21 announcement, this newspaper made a mistake, from his standpoint. We put "Dr." before his name. Not that he wasn't entitled to it. He held a doctorate of philosophy. But he didn't want it. He insisted on the plain and democratic "Mr."

He knew that doctors of philosophy often were "doctored" by people wishing to flatter them. He knew some used it as a status symbol, to advance themselves in their profession.

In an interview with a Journal reporter after he moved here, he announced firmly: "Call Me Mister." Then he explained why:

One of his old teachers said years ago to him: "If you deserve to be called Mister, all those other titles don't mean a thing. I would rather be called 'him'."

Mr. Oakes' position on what may seem a minor matter to some people offers a telling measure of his modesty, his sense of the fitness of things, and his dislike of self-glorification. It was especially striking in a man who had given so much of his life to education.

He was among outstanding Brookfield residents who prefer not be doctored even though they hold doctorates of Philosophy or divinity. The Brookfield Journal avoids this title except for physicians, dentists and veterinarians, because of the confusion it causes among readers.

Another mark of Merwin Oakes was to be found in our interview.

"Mr. Oakes himself is a person of few glances at the past. His house may be on a rock ledge, but some of his strongest views are concerned with being put on the shelf."

In other words, retirement was forced upon him because of chronological age. But he was determined not to dry up and blow away. When he moved here, he offered his services as a teacher of sciences free of charge to schools in Brookfield and this area. They were used in some cases.

But he found his new career in conservation, as Mrs. Hagmayer proves. Before long he was a member of the Brookfield Conservation Commission. He threw himself into this work energetically.

He was one of the first workers for a parkway for beautification and for recreation along the new Route 7 expressway.

To show how much he lived in the present as a man young in heart rather than an oldster living only in memories, he had an idea at a work session on the parkway.

The idea was to form a Still River Watershed Association of public-spirited and con-

servation-minded citizens in towns through which the river or its tributaries run.

Characteristic of a man young in spirit he did something about it. He came to The Brookfield Journal. On page three of our Feb. 8 issue will be found an interview with Mr. Oakes, and his picture. It outlines his idea.

On page six of today's Brookfield Journal will be found an editorial entitled "Rally for the River." It supported Mr. Oakes' idea of such an association. The same editorial was printed last week in the New Milford Times, in the hope that New Milford people would join in founding the Still River Valley Watershed Assn.

But the Times editorial in The Times had a few sentences more. These sentences advised interested people to contact Mervin Oakes in Brookfield. Sadly, this has been taken out of the editorial in today's Journal.

But it is our hope that his friends and the friends of conservation, interested in saving and enhancing the beauty of our countryside will take up his idea of such an association and make it a reality as a living memorial to Mervin Oakes.

The world in general and Brookfield in particular are better for having had Mr. Mervin Oakes in them.

FOR MR. OAKES

by Nancy Hagmayer
Vice-chairman, Brookfield Conservation Commission

To serve on a commission or a committee; to go on a hike or to a conference with Mervin Oakes was an experience with a very particular quality.

Those of us fortunate enough to have been on the Brookfield Conservation Commission became aware of this soon after he was appointed a fellow member and met with us each month at the Town Hall.

Before meetings came to order he was always deeply engaged in some discussion involving wild flowers or photography or Indian relics or geological outcroppings and as the discussion continued, one became aware of the feeling that he had been searching and that his search had been rewarded and that if you would go to a certain spot you too would see the best stand of Dutchmen's britches to be found in New England.

Or maybe he had noticed in your garden a certain lily that he had been looking for and if you would be willing to divide it with him you could have a choice of any lily in his garden and they, too, were very special and the result of years of selection.

He always imparted this marvelous feeling that the earth abounded with very special treasures of whose existence he knew and that the greatest sport in life was tracking each one down and sharing his delight with anyone else who cared.

Being a field biologist he was also generous about sharing the deep and extensive knowledge he brought to each new discovery.

Once engaged in any kind of search or research, time meant little to him. On several occasions when large groups hiked over the Gurski hill and down the valley of Merwin Brook they would tend to split up, some racing ahead enjoying the physical exercise and others going at a slower pace.

The trail ended at Obtuse Rd. North where hikers would rest in the sun waiting for stragglers to catch up. For maybe 20 minutes groups emerged from the woods and then, at least a half an hour later, beaming and looking fresh as a daisy Mervin Oakes would appear surrounded by eight or ten hikers absorbed in his conversation and all of them completely oblivious to the fact that a search party was being organized to rescue them.

This was a true picture of Mervin Oakes to the very last days of his life. Those of us who knew him best will always think of him looking, finding, sharing and above all, relishing the simple splendors of the natural world.

Dr. Oakes was recipient at the Thirty-First Science Education Recognition Award.

Quoting in part from the April 1962 Science Education:

Dr. Oakes was born in Lecompton, Kansas, July 23, 1892. His parents were Isaac Lincoln Oakes, born in Iowa, and Alice Andis Oakes, born in Indiana. The father was a Methodist minister and hence was constantly changing residence. When Dr. Oakes was born, both parents were in attendance at a church college, Lane University in Lecompton. When young Oakes was only a few months old, the parents moved to Westerville, Ohio, where they graduated from Otterbein College, when he was two years old. He recalls his parents telling him that his mother made him a miniature cap and gown and that he sat on her lap during graduation exercises.

Both parents had grown up in the wide-open spaces of central and western Kansas. Both parents passed away about fifteen years ago. Paternal and maternal grandfathers were in the Civil War in the Union Army. Both had been farm boys.

One of his grandmothers, Sarah Andis, Née Stone, had a brother, W. G. W. Stone, who was State Forester in Colorado. Mr. Stone was a close friend of Gifford Pinchot, one time Governor of Pennsylvania, who later became prominent in the Theodore Roosevelt administration. (Mr. Pinchot was the founder of our Federal Forest Service and was described by the late Senator Richard L. Neuberger of Oregon, he himself an ardent conservationist, as "America's first great conservationist.") Dr. Oakes recalls a visit as a small boy to Mr. Stone who lived in Denver and while there visiting his first science museum in the state capitol building. Grandmother Oakes, Née America Sutton was renowned and skilled in weaving and other handcrafts.

Dr. Oakes was the oldest of five children. A sister Mercil Alice died at the age of two years and a brother Millis Arvene, formerly postmaster at Colton, California, died suddenly from a heart attack last September. A sister Mary Ethel (Mrs. Howard Butterfield) lives in La Crescenta, a suburb of Glendale, California. She teaches mathematics in the Glendale High School. She plans to retire this June. Mr. Butterfield, former Head of the Physical Education Department in the Glendale High School, retired a few years ago. A younger sister, Maude Elva (Mrs. A. Volandri) lives in San Francisco, California, and teaches mathematics in a San Francisco high school.

Dr. Oakes married Grace Thorne of Landrum, South Carolina, May 28, 1919. Her mother, Leila Boone Thorne was a descendant of Daniel Boone. Both of her grandfathers were in the Confederate army. She is a member of the United Daughters of the Confederacy and Daughters of the American Revolution. Ancestral names include Boone, Hampton, Wilson, and Alexander.

The Oakes are parents of a son "Bobby"—Mervin Oakes, born in Los Angeles, California. He and his wife Leslie, Née Greaves, live at 339 Summit Avenue, Norwood, New Jersey. Both Bobby and Leslie are excellent on the flute. She formerly was a member of Phil Spitalny's All-Girl Orchestra. Both are active in community orchestras, although for many years he has pursued a business career dealing with swimming pool equipment and supplies.

There are three grandchildren: Nancy Ruth, 16, in her third year at Dwight School for Girls, Englewood, New Jersey. James Greaves Oakes, 14, is in his first year of high school at Englewood School for Boys. Donald Mervin Oakes, 11, is in the sixth grade, Norwood Public Schools.

A former Methodist, Dr. Oakes now attends the Flushing Unitarian services.

Dr. Oakes entered the first grade in Harveyville, Kansas. Because the school was located two miles north of town, young Oakes had to walk both ways. His fondness for wading mud-puddles during rainy weather resulted in the nick-name "mud-hen." He attended eight different grade schools before completing the eighth grade in Douglas, Arizona. Towns in between included: Havensville, Kansas; Evanston, Wyoming, and Ottawa, Kansas. Dr. Oakes vividly recalls when he was ten years old:

The summer (1902) when I was ten years old, the entire family in a covered wagon (which my father had especially built) both parents, two boys, two girls—spent the whole summer on a camping trip through the entire length of the state of Kansas and into Colorado, including the Garden of the Gods. There was a camp grounds nearby, somewhat like a trailer court nowadays, where we spent two or three weeks. During that time we went on a toll road up between Pikes Peak and 'Baldy' Peak. There were two other wagons with us, one family we had known in eastern Kansas; the other acquaintances from the camp at Colorado Springs. I remember prairie dog towns, at one of which I killed a rattler with a bull whip. Game along the way supplied most of our meat. It was a memorable experience!

The summer after his graduation from grade school, the parents moved to Naco, Arizona, a town without a high school. The father's "charge" (parish) was 75 miles across the border in the mining town of Cananea, state of Sonora, Mexico. Young Oakes went with his father and worked in the Cananea Consolidated Copper Company store where he picked up a bit of Spanish and a severe case of typhoid fever. Late in the fall of 1907 the family moved to Grand Terrace, two miles south of Colton, California. Here Dr. Oakes entered the Colton High School two months late. After four years of English, Latin and History, three years of mathematics, and a year each of Chemistry and Physics, he graduated in 1911 in a graduating class of eleven members. Dr. Oakes ruefully recalls making a grade of "C" one semester in high school chemistry, his only grade lower than "B" in either high school or college. In the fall of 1911, he entered the University of Southern California in Los Angeles. At that time the Liberal Arts College was housed in a single building, Bovard Hall, named in honor of President George Finley Bovard. Dr. Oakes, majoring in Zoology, graduated from the University of Southern California in 1915. From 1915 to 1917, he attended Drew Seminary Jersey. After a special course at the YMCA College in Springfield, Massachusetts, Dr. (now Drew University) at Madison, New Oakes was assigned to the Army YMCA at Camp Wadsworth, Spartanburg, South Carolina, about September 1, 1917. He was stationed at Camp Wadsworth for twenty months. An M.A. degree in Zoology from Columbia University (1924) and a Ph.D. degree from Teachers College, Columbia University (1940) completed his academic training.

Teaching experience for Dr. Oakes began when he was a laboratory assistant in the Zoology Department of the University of Southern California for two and a half years and at the same time teaching a class of English for Foreigners in the downtown Los Angeles Settlement House (1913–1915). During 1920–1923 he taught English in Clemson College, Clemson, South Carolina. In an interview before this appointment, the Associate Director of the Academic Division of Clemson College told Dr. Oakes:

> Yes, I know your major was Biology (Zoology) but there is no opening in that department. We do badly need an English teacher. All that the College rules require for this post is an A.B. degree, which you have.

In the summer of 1923 Dr. Oakes went to New York City so that he could pursue graduate work at Columbia University. He had a full-time teaching schedule in General Biology and Comparative Anatomy laboratories at Washington Square College of New York University. During 1927 and 1928 he taught Biology in the James Monroe High School, Bronx, New York City Public Schools. In the meantime Dr. Oakes had completed course work for a Ph.D. degree in Zoology at Columbia University and had had additional courses with Dr. Samuel Ralph Powers at Teachers College. During 1928–30 he was assistant and later instructor in the Department of Natural Sciences, Teachers College, Columbia University. During 1930–31 he taught high school biology in the Lincoln School of Teachers College. During the summer session of 1931 Dr. Oakes taught courses in Teachers College. During this time he and Dr. Herbert Arnold taught a field course in science at Teachers College.

In the fall of 1931 Dr. Oakes was appointed Head of the Science Department, New York State Normal School, Fredonia, New York. Here he remained until 1935. During 1935–36 he taught English at Mars Hill Junior College near Ashville, North Carolina, while the chairman of the department was on sick leave because of sciatica. During 1936–37 he was Principal (27 teachers) and taught high school biology and general science in the Greens Creek Consolidated Rural School, Polk County, near Tryon, North Carolina. In the fall of 1937 Dr. Oakes went to Queens College of the City of New York City (now part of the University of New York City). Here he has had the rank of Instructor, Assistant Professor, and Associate Professor of Biology. He will retire September 1, 1962 because of what he describes as "statutory senility" (mandatory state requirement).

Mrs. Oakes who has served as Order Desk Librarian at Queens College for 18 years will retire in another year. Then the Oakes plan to vacate their Flushing home for a place as yet not determined.

Publications:

(With Maxie Nave Woodring and H. Emmett Brown) *Enriched Teaching of Science In High School,* Bureau of Publications, Teachers College, Columbia University, 1928; 2nd Revised Edition, 1941.

(With Samuel Ralph Powers) *Oakes—Powers Test In General Biology,* Bureau of Publications, Teachers College, Columbia University, 1928.

Children's Explanations of Natural Phenomena (Doctoral Dissertation), Bureau of Publications, Teachers College, Columbia University, 1947.

Articles:

"General Biology," *New York State Education,* October, 1931.

"Elementary Science," *New York State Education,* April, 1932.

"How Do Children Explain Things?", *Science Education,* February, 1932.

"How Many Mendel's Laws Are There?", *The Teaching Biologist* (New York City Biology Teachers Association), April, 1942.

"Science in Soviet Russia, A Bibliography," 1945.

"Explanations of Natural Phenomena by Adults," *Science Education,* April–May and October, 1945.

"Science Education and International Understanding," *Science Education,* April, 1946.

"Science from the Development Point of View," *Science Education,* April, 1951.

"Dinosaurs—Then There Were None," *Science Education,* October, 1957.

"Variations In Dahlias," *West Coast Dahlia,* Volume 3, No. 6, 1958.

"Explanations by College Students," *Science Education,* December, 1957.

"Three Classroom Procedures for Presenting the Concept of *Mechanism* in Biology," *Science Education,* February, 1959.

"Watch Your Language—How to Avoid Teleology," *Science Education,* February, 1960.

"Teleology In College Biology Textbooks," *Science Education,* February, 1960.

"Teleology and Elementary Science," *Science Education,* February, 1961.

"In Favor of Discrimination," *Science Education,* April, 1962.

Membership in Organizations:

National Association for Research in Science Teaching, National Association of Biology Teachers, National Science Teachers Association, Council for Elementary Science International, American Association for the Education of Teachers in Science, National Education Association, American Association for the Advancement of Science, American Horticulture Society, New York Biology Teachers Association, New York General Science Association, American Nature Study Society, National Audubon Society, American Forestry Association, American Genetic Association, Wilderness Society, American Museum of

Natural History, New York Botanical Garden, Brooklyn Botanical Garden, Utah Nature Study Society, St. Croix Museum (Virgin Islands), Queens Botanical Garden Society, International Society for General Semantics, New York Society for Medical Research, Putnam County Extension Service Society, North Salem (New York) Library, Harlem Valley Mens Garden Club, Topical Association (Philately), Society for the Preservation of Covered Bridges, Franklin Minerals Association, Co-Op League U.S.A., American Dahlia Society, Rollin' Rock Club, American Hemerocallis Society, American Gloxinia Society, American Gourd Society, Phi Delta Kappa, and Kappa Delti Pi.

Honors:

Fellow American Association for the Advancement of Science; Listed in *American Men of Science;* Secretary, Science Council, New York City Federation of Science Teachers Associations, 1947; By invitation, participant, Sixth Annual Alumni Conference, Teachers College, Columbia University, 1954; Chairman, Program Committee, Sixth Annual Queens College Conference on the United Nations —Theme: "Can Man Control Nuclear Energy?"; Vice-President (1961) and member Executive Board for four years, Harlem Valley Mens Garden Club; President (18 years) and member Board of Directors of Flushing Consumers Cooperative (for 20 years); Secretary, Department of Biology, Queens College, for 20 years or so; Department Representative on Queens College Biology and Education Concentration Committee; Faculty Sponsor for ten years or so, Queens College Rifle Club and Rifle team; Boy Scouts Counsellor (i.e. examiner) in astronomy, geology, and nature for several years; member of the National Association for Research in Science Teaching Committee (1958–59) that rewrote the NARST Constitution; member of a number of committees and panels in college and science teachers organizations; and Advertising Manager for *Science Education,* October 1944 through December 1945.

As to a philosophy of education, Dr. Oakes writes:

> Not sure I have such; at least, I have never formulated. As a teacher I believe I have tried to pass on knowledge, interest—fascination for science. I've neither babied nor forced those in my classes. I consider each of them to be a person; an adult. I do not consider teaching to be a funnel or a siphon of anything. If a learner does not educate himself, he will not be educated. The teacher has the same role as a coach, although of course, that's not all there is to it. To be sure, as in the Parable of the Sower, response is not uniform. In some instances, a few seem to show that they expect pampering, and then grit their teeth and step toward manhood.

As for hobbies, again Dr. Oakes writes:

> I have far too many!
>
> 1. I have collected Indian arrowheads since I was eleven.
> 2. My stamp collection, almost as long standing, is what is now known as "Topical." For some time several years ago, I collected only those stamps showing some aspects of the sciences, including Music as a branch of Physics—that is now too vast for me, so now it has narrowed down to a few groups of animals: Marsupials, Whales, Primates (other than man); Plants: Algae, Fungi, Orchids, Cactus; and Minerals (especially from Switzerland).
> 3. Minerals, especially crystals and semi-precious stones in bola ties for my sports shirts in summer and in cuff links and tie clasps otherwise.
> 4. When I was in high school and college, I was what was then called a "Kodak Fiend." The last few years I have been interested in my Zeiss Contaflex 2, especially color slides of wild flowers, birds, etc. I'm no expert, but its fun.
> 5. When I was in Fredonia, I kept rabbits (especially the Himalayan breed) and tropical fishes; now it's flowers: Amaryllis, Gloxinias and other house plants; at our cottage on Peach Lake, near Brewster, Putnam County, Hemerocallis (daylilies), Dahlias, Gladiolus, etc. This gives me a substitute for golf.
> 6. Pictures of, and books about Covered Bridges.
> 7. Specimens of, and books and articles about Majolica—a type of pottery. This is one focus of a pastime which Grace and I indulge in enthusiastically—country auctions.

The writer first met Dr. Oakes and his gracious wife Grace when we were both students at Teachers College in the late 1920's. A warm personal friendship has

spanned the succeeding years. We have always been impressed with his emphasis on preciseness and attention to detail. This characteristic is evident in his doctoral dissertation *Children's Explanation of Natural Phenomena,* his studies of teleology (the basis of a series of articles published in *Science Education*), and the revision of the NARST Constitution, for whose rewriting he was largely responsible.

Among his major accomplishments were the findings in his excellent doctoral dissertation, particularly the refutation of Piaget's conclusions. The series of articles on teleology, published in *Science Education,* have been major contributions in this area. He has been an excellent class room teacher of Biology, Science, and English over a period of nearly fifty years. Thousands of students, prospective teachers, and teachers have attended his classes and have been influenced by his scientific thought and philosophy.

To him who in love of Nature holds
Communion with her visible forms,
She speaks
A various language
Thanatopsis—William Cullen Bryant

To be seventy years young is something more cheerful and hopeful than to be forty years old—Oliver Wendell Holmes

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It is with a feeling of pride that the Thirty-First Science Education Recognition Award is made to Dr. Mervin Elijah Oakes, effective, devoted teacher, capable author, sympathetic counselor, respected colleague.

Clarence M. Pruitt

ELISHA L. FISHER

1884–1967

Probably no other editor of a professional magazine, or at any rate a science education professional magazine, has had the privilege of honoring their first high school teacher. At least we know of no such case. So it is our purpose to honor and pay our respects to a truly fine teacher of more than forty years and a man of the highest standards, professional and personal. Thus we are taking advantage of this once-in-a-lifetime opportunity.

Elisha L. Fisher was our first high school teacher some fifty-six years ago. Born and reared on a farm, we first came in contact with Mr. Fisher as our first high school teacher in the fall of 1911 in the small southern Indiana town of Birdseye. Mr. Fisher had initiated the Birdseye High School a year earlier in the fall of 1910. Our class had some 13 or 14 members. Mr. Fisher initiated the writer into the study of science—botany, physical geography, and

ELISHA L. FISHER

physics—and three years of high school latin. More than any other teacher, Mr. Fisher made us a student, if we can claim such a distinction. Under him we learned how to study. In retrospect we consider Mr. Fisher to have been an outstanding high school classroom teacher—to a degree stern and rigid, but always fair and just, ever willing to aid a student in time of difficulty. He expected us to do our best and we tried not to disappoint him. Some of our classmates using high school "ponies" learned that Mr. Fisher did not have a head of flaming red hair for nothing.

Four years of high school under Mr. Fisher was a good preparation for entrance to Indiana University. We were also fortunate to have had another fine high school teacher, Mr. Fred N. Anderson. In retrospect we believe these two teachers were truly superior teachers—as much superior to the students they were teaching (in knowledge, learning, teaching techniques, culture, leadership, personal standards) as modern high school teachers are in general, to their present-day students. Certainly these two high school teachers do not suffer in any way in comparison with present-day high school teachers. Actually we believe they were relatively superior. (Note: we would welcome an article by any reader who would care to compare their high school teachers of some forty-five to fifty years ago to present day high school teachers.)

Through the years Mr. Fisher and the writer maintained some contact with each other. Mr. Fisher was always a fine supporter of *Science Education*—now and then giving us needed courage to carry on. How much a debt one owes to a fine teacher is beyond estimation. Fortunate indeed were we to have had Mr. Fisher as our high school teacher.

Born September 21, 1884 in Brown County, Indiana, Mr. Fisher received a Bachelor of Law degree summa cum laude from Central Normal College, Danville, Indiana, in 1909 (admitted to Indiana Bar in June 1909). Standard Normal Teachers Degree from Central Normal College, 1915. A.B. 1917, magna cum laude—major political science, and M.A. 1920—major education, Indiana University. He was a member of Phi Beta Kappa, honorary scholastic society.

Mr. Fisher was a member at Malta Lodge F&AM; DeWitt Clinton Consistory, Scottish Rite; an honorary member of the Grand Rapids, Michigan Bar Association, and a member of local, state and national teacher associations.

Teaching experience—

Birdseye, Indiana, 1910–1915, superintendent of schools (organized the high school there).

Leesburg, Indiana, 1917–1918, superintendent of schools.

Freelandsville, Indiana, 1918–19, superintendent of schools.

Corydon, Indiana, 1919–21, superintendent of schools.

Columbia City, Indiana, 1921–23, superintendent of schools.

South High School, Grand Rapids, Michigan, 1923 until retirement in 1951—History.

Mr. Fisher passed away from a coronary thrombosis in the Butterworth Hospital in Grand Rapids, Michigan, October 13, 1967. Burial was in the Woodlawn Cemetery in Grand Rapids. Mr. Fisher was a member of the Central Methodist Church, Cedar Springs, Michigan. Mr. Fisher had lived with his daughter Imogene (Mrs. John S. Straw) for the last 18 years following the death of Mrs. Fisher.

Mr. Fisher married Elizabeth Ann Dillon who passed away March 10, 1949. They had four daughters who survive with 9 grandsons, 10 granddaughters, 3 great-grandsons, and one great-granddaughter. Also surviving is a sister, Mrs. Sarah Waggoner, Odom, Indiana, and a brother, Virgil Fisher, Worthington, Indiana.

Virginia (Mrs. Sidney Nadolsky)
1036 Giddings Avenue S.E.
Grand Rapids, Michigan.
Children: David (27), pharmacist, Detroit, Michigan; Karl, (18), Fresh-

man at Hope College; Rosemary (15), Freshman in High School.

Irene (Mrs. Robert Straw)
2507 Godwin Street S.E.
Grand Rapids, Michigan
Children: Donna (27), Karen (24) (both married); Roger (19), Sophomore, Grand Rapids Junior College; Joni (15), High School Freshman; Johnny (9), Fourth Grader.

Imogene (Mrs. John S. Straw)
1560—19 Mile Rd. N.E.
Cedar Rapids, Michigan 49319
Children: Susan (16), Sophomore in High School; Jeffery (13), Eighth Grade; Becky (11), Sixth Grade; Scott (2).
Incidentally, Irene and Imogene are twins and they married brothers.

Jane (Mrs. Paul V. Merren)
418 S. Bower
Greenville, Michigan.
Children: Barbara and Beverly (twins—21), Seniors, Central Michigan University; Michael (18), Freshman at Ferris State University; Jenifer (17), High School Senior; Patrick (15), High School Freshman; Pamela (13), Eighth Grade; Stephen (11), Sixth Grade.

Quoting Imogene:

> Dad was a stern father, but a permissive, loving, indulgent grandfather. Our children were richly blessed. He was an avid gardener and loved working in the soil (flowers, vegetables, plants, tree grafts). He was actively interested in people and alert to the very end. He could carry on a conversation with anyone on any subject (including children). He was continually reading and learning. He kept up with the latest in dairy farming, politics, stock market, world economics, space explorations, scientific advances, war in Vietnam.
>
> The stories, games, songs, and rhymes he indulged on the children they will never forget. He thoroughly enjoyed children and they enjoyed him.
>
> This was my father as I think of him.

A nice tribute by a daughter to her father!

Thus it is a rare privilege to honor a teacher who contributed so much to us personally and professionally. More teachers of Mr. Fisher's ability and character would and could have solved many of the learning difficulties and deficiencies in modern-day education.

Clarence M. Pruitt

RESIDUALS FROM A DECADE OF CRITICISM *

Herbert A. Smith

Director of Teacher Education, Colorado State University, Fort Collins, Colorado 80521

INTRODUCTION

Criticism of education is not new and it is apparently as longstanding as the written record of mankind. It does not even require much imagination to visualize the shamans of ancient primitive tribes sitting around the council fire debating various educational theories. Man has always shown a concern for the proper upbringing and education of his offspring, inspired, no doubt, by a variety of motives, ranging all the way from children viewed as a cheap "slave labor" source to the highest of altruistic purposes. The molding, and I use the word advisedly, of the young in terms of their anticipated roles in society has long preoccupied the thinking of men. Perhaps, too, some of the continuing concern for education reflects the unconscious desire of the parent to create the child in his own image, thus, providing an extension of himself which will endure beyond his own lifetime. Through his child the parent obtains a kind of immortality and establishes his

* Vice-Presidential Address, Section Q. American Association for the Advancement of Science. Presented at New York City meeting December 27, 1967.

link with eternity. Thus, concern for education has had a profound appeal over the ages, ancient to modern.

With the rise of civilization and the development of specialized tasks within the community, man found it expedient to institutionalize the process of education and thereby created an eternally productive field for the educational critic. The process of institutionalizing education is a continuing one and it is quite possible that there has never been a decade in all the history of mankind in which this process has had more attention than in the last. In our own country we have seen the entrance of the federal government into educational matters at all levels on an immense scale. This has had tremendous effect on the educational balance in finance, curriculum and control among the federal, state and local authorities. But such changes in control, financing, and management of schools are not unique to the United States; they are paralleled by educational revolutions occurring in many lands. The underdeveloped countries are tremendously concerned with education and the international aspect of education has become increasingly important. These are cited merely to point out that there is a world-wide consciousness of the rising demands for sound education and a recognition by every modern nation that soundly educated citizens are the very basis of national survival. Problems of dwindling national and world resources, increasing populations, decreasing food supplies, proper land utilization, and water resources present issues which cannot be much longer unresolved. In such a period there are ample targets for the critic's attention and, if he is so disposed, for his invective.

If the critic has been around so long, why then is there any urgent concern about him at this point in time? Perhaps many reasons could be adduced to account for the particularly vicious and vitriolic attacks on education, particularly public education at the elementary and secondary levels, during the last decade. It would surely be a mistake to think of all critics as members of a single species. They might be classified in many ways. Clearly, some of them are subversives and their affiliation and identification with organizations on the United States Attorney General's list of subversive organizations are matters of record. Some are clearly exploitive and their motives as well as their qualifications for any legitimate criticism of the public schools are clearly suspect. Some are certainly legitimate critics in the sense that they are not promoting ulterior ends but are genuinely seeking, as they see it, an improved educational system or product. This is not to say that all legitimate critics make either reasonable statements or assume defensible positions. This category includes a large number of cranks, deluded misanthropes, and misinformed academicians as well as critics who are thoughtful, perceptive and fully justified in the positions which they take. It is essentially the non-constructive and irresponsible critics of whatever category, which represent the special concern of this presentation. It is accepted as self-evident that constructive criticism is indispensable.

THE NATURE OF THE CRITICISM

A recent penetrating study of critics and criticism has been made by Raywid. On the basis of her intensive study she came to the conclusion that "often it is our way of life that is being challenged rather than our theories of education." [1] It is obvious that what one's convictions are about what the schools ought to do will be shaped by the concepts which he holds of the nature of man and society. Too often the public schools are merely the most convenient, most vulnerable, and most defenseless agency which can be attacked. Raywid's extensive analysis shows beyond any doubt whatever that a great many of the critics of education can be described as members of the extreme right-wing. They hold ultra-

[1] Mary Alice Raywid. *The Ax-Grinders*. Macmillan Company, New York, 1963, p. 2.

conservative ideas, not only in regard to the schools, but also in regard to economics and politics. Some of the critics, including the infamous Council on Basic Education, have been supported by foundations which can only be described as ultra-conservative. Miss Raywid has shown that the Council for Basic Education, the National Economic Council and the Foundation for Economic Education are all supported by grants from the Volker foundation. As evidence of their kindred philosophies, the National Economic Council has opposed federal aid to education as socialism, the Foundation for Economic Education views education as a private responsibility, and the Council for Basic Education maintains that the correlation between cost and academic achievement is practically zero. In this latter connection, the comparison between per pupil costs in Mississippi and New York and the differences in levels of educational achievement in these two states seems to escape them entirely.

Raywid has proposed the hypothesis that the root of many criticisms can be traced to a fundamental difference in the values held by critics and by typical educators or, perhaps more accurately, differences in the implications which values have for educational practice.[2] Thus, though both critics and educators might insist that equality of educational opportunity is fundamental in American education, the critics might hold that such opportunity is provided when all students are given an appropriate exposure to a rigorous presentation of a discipline, such as mathematics, in the classroom. To such critics, those students who, for a variety of reasons, may not be able to keep up would have at least had their opportunity! To educators, this is a totally inadequate concept of what constitutes equality of educational opportunity for it overlooks ability differences, cultural deprivation, maturation factors and a host of additional psychological and sociological aspects. Such a view provides small solace to those who *cannot* achieve the standards set.

Again and again through the writings of the critics, one is impressed by their concern with the "intellectual elite." Their philosophy as it emerges from the reading of their writings would seem to be more appropriate to the gymnasia of the European systems than to the comprehensive high schools which have evolved in this country. It is a concept of education appropriate to a ruling aristocracy—a position long since rejected by American citizens.

What would be done with students who are unable to meet the highly abstract and demanding programs often espoused by critics is somewhat obscure. Such critics are typically against "vocationalism" in the school. Although not clearly enunciated, and with good reason, there are two recurring themes which seem evident by implication in the critic's broadsides. These are: abandon compulsory school attendance and eliminate the comprehensive high school! This attitude flies in the face of the fact that, at the present time, teenagers who are not scholastically able cannot find productive employment in the world of work and that a genuine concern for their personal development through some kind of appropriate educational experience is essential. It also ignores the fact that the comprehensive high school is a concrete example of the American concept of democracy at work.

The trend nationally and historically has been toward an ever greater concern for the education of the handicapped, minority groups, and for plain, average students, although this concern is not always reflected in sound educational practice. This has been the will of the American people speaking through their elected representatives for far over a century and it is fully justified on humanitarian, democratic, and economic grounds. Much recent federal legislation has been a further extension of this philosophy. The critics also beg the question of whether or not a highly abstract and theo-

[2] *Ibid.*, pp. 185–198.

retical education is even the best education for *all* of the most gifted students. At a time when our citizens and the world are in danger of strangling in their own biological and technological excreta, our critics would have us employed with excessive dallying in the ethereal world of higher order abstractions. This is not intended to denigrate the need and the significance of abstractions but it does insist that such concern must be tempered by the obvious relationship which education must have to the real world.

There seems to be a belief among the critics that geniuses can be educated. This is clearly open to question and it is all too apparent that many of the geniuses of the past did not depend for their accomplishments on any formal educational process. Essentially, they have been self-educated. As exhibit A for my argument, I would propose the names of Einstein, Churchill, and Srinivasa Ramanujan for your consideration. History is full of examples of geniuses who were martyred by their own equally, or even better educated, colleagues. I might cite the further fact that we have thousands of scientists who are good solid Ph.D.'s, but few of them have shaken the world by generating monumental new theories or discoveries. Only a handful of them might be described as scientists of "magnitude one." Most of them are involved in relatively pedestrian types of research. Furthermore, studies have shown that many of them were not particularly extraordinary, either in aptitude or achievement in the lower schools. These statements are in no way intended to detract from the great achievement of scientists as a group but they do perhaps have some relevance to the point that educational systems are not designed to produce geniuses. The genius is in all probability an accident and a byproduct which occurs in any educational system, and perhaps rather in spite of it, than because of it. Educational systems are designed to meet the needs of people, and in our country, surely the ideal is to meet the needs of all the people. This includes the handicapped as well as the gifted, the culturally deprived as well as the privileged, and urban as well as the rural child.

The Specific Targets

It seems probable that very few aspects of education have escaped the attention of critics. However, their attention has tended to concentrate on selected elements.

1. Textbooks. The charge of subversion has been a popular one but textbooks are criticized on other grounds such as the inclusion of unsuitable material, advocating wrong methods, or that they reflect a "progressive" education point of view.
2. Teachers and teacher preparation. Teachers have been criticized on the ground of their lack of loyalty or patriotism. They have been accused of being un-American, of harboring the wrong opinions, of having purposes contrary to the best American tradition (narrowly defined in terms of the particular bias of the critic and the organization represented). The preparation has been criticized, usually in terms of not enough content, and too much professional training. Professional training is an anathema to them, although strangely they wind up recommending it, but it must be their brand!
3. The curriculum. Here life adjustment has been the real scapegoat but other "nonessentials" of the curriculum are also criticized. Presumably, nonessentials are those subjects which do not find their counterparts in the typical liberal arts curriculum of colleges and universities. The charge is made that schools promote ultra permissiveness and, in general, exercise a lack of discipline.
4. Sectarianism and godlessness. Strangely enough, the schools are accused with equal vehemence of both practices which is a little hard to reconcile.

5. Anti-intellectualism. Although this is seldom defined, the charge is heard frequently. The implication is always plain that schools do not desire to provide sound education.
6. Money. The theme is recurrent that too much money is spent on the schools and it is spent on the wrong things. The charge is made, patently true, that the cost of instruction in the academic areas, which constitute the critic's preferred curriculum to the exclusion of what they define as fads and frills, is cheaper.

TO WHAT EXTENT ARE SUCH CRITICISMS VALID?

As indicated earlier, the validity of the criticism will vary, in part, depending upon the particular value orientation of the observer. It is safe to say that the criticisms range from zero validity in some instances to substantial validity in others. Unhappily, a great deal of the criticism is essentially nihilistic. Nothing follows from it. Conant and Melby have both paid their respects to criticism of this kind. Conant states:

> I can understand, of course, that hit-and-run attacks by critics who always seem to disappear when constructive and continuous action is required, or who do not give any serious study to school problems before launching an attack, provoke legitimate anxieties. Such critics appear to public school people as connivers anxious only to gain a public forum in order to enhance their personal prestige or fatten their pocketbooks. As for criticism from the members of the academic faculties, the most common rejoinder is 'You can't get them to spend even a day trying to handle public school classrooms or going over the problems an administrator faces.' This charge is in too many cases just.[3]

Melby states:

> . . . it is hard to take criticism which appears to ignore the basic problems of one's professional area, which focuses the worst possible examples of professional accomplishment, over-generalizes from specific examples and completely ignores trends toward improvement within the profession.[4]

In somewhat blunter language than Conant and Melby employ, much of the criticism is glaringly dishonest. The use of propagandistic devices and of deliberate and repeated falsehoods is evident and a general manifestation of a lack of integrity is reflected in comments of some of the worst critics. Their methods are characteristic of those used by *agents provocateurs.*

Although an exhaustive refutation might be presented of many of the criticisms made relative to the six areas identified above, time and space will not permit such an extended treatment here. However, a few illustrations of some of the charges that fit into several of the areas above might well be made. It is charged by the Council on Basic Education that "Your modern educator says not only that the school must deal with every side of the child's life but he often insists that all sides are of equal importance. . ."[5]

That's a lie!

Another example, "Derived from the teaching of early progressives, this dogma [of freedom in the classroom] implies that discipline, both in the sense of control of conduct and as the process of directed teaching, is somehow harmful to the youthful personality."[6]

That's a lie!

The Council states: "Many educators, perhaps a majority, feel that psychological and sociological research has established enough 'truth' about the nature of the child and the learning process to provide infallible guides to method and even content in education of the very young."[7]

That's a lie!

Perhaps one of the most devastating charges that is made over and over again with virtually no semblance of truth is the following: ". . . the important element in professional preparation for teaching and

[3] James B. Conant. "The Educational Establishment." *Phi Delta Kappa,* 46: 192, December, 1965.

[4] Ernest O. Melby. "Roots of Criticism." *Childhood Education,* 40: 118, November, 1963.

[5] Council on Basic Education. "The Seven Deadly Dogmas of Elementary Education." *CBE Bulletin,* 2: 4–5, February, 1958.

[6] *Ibid.,* p. 5.

[7] *Ibid.,* p. 7.

administration is not knowledge of what is taught but knowledge of how to teach and knowledge of the child." [8]

That is a baldfaced lie!

Finally, listen to this classic criticism from our famed Admiral. [Parenthetically, the construction of the first sentence is hardly a model of lucid English composition.]

> 'Education courses' which count toward certification requirements may be such complicated and difficult matters as how to ventilate a classroom properly, how to run a tape recorder, how to teach the art of listening, group dynamics, 'nesting' hand-painted tin cans, and classroom democracy. Courses of this kind are made the criterion of 'professional' competence in a teacher. So equipped, he is considered qualified to teach *anything*.[9]

This is *both* a lie and a distortion. I do not know one educator who does not believe in reasonable competence of the teacher in the field in which he is conducting instruction but he obviously doesn't need to be a Ph.D. in physics to teach a creditable seventh grade science class.

The effectiveness of the critics is hard to understand since much of what they advocate is swimming against the tide. For example, educators are not solely, or even largely, responsible for the addition of such subjects as typewriting, auto-mechanics, homemaking, driver education, physical education, and other similar subjects to the curriculum. Popular demand by the American public and a willingness to pay for such additions have been evident. This is not to deny that every students' program should include a large share of what our critics call the "solid" subjects but it does not necessarily imply the versions so frequently demanded by them.

THE EFFECTS OF CRITICISM

Let me consider the impact of the recent large-scale curriculum revisions in science. In general, these courses reflect an "elitist" approach and I think there is not the slightest doubt that many students of even excellent ability are showing avoidance reactions to science because of this fact. All students capable of being in high schools ought to be taking more and not less science. Science should be for all citizens, not just for future scientists. I think the justification for such a view is self-evident in this time and place. The point is that the critics have influenced curriculum and instructional practices in very adverse ways. They have taken the position that more content for both teachers and students was the major key to the solution of educational problems. Acceptance of this view has had disastrous effects on a large portion of the school population and has encouraged subject oriented teachers to take pride in their student failure rates rather than in their student success rates.

A really distinguished American educator has had the following pertient comment.

> When one takes inventory of the areas in which there is the most work unfinished one finds in the writings of the critics precious little, if any help. Proposals such as to curtail sharply the professional work in teacher education, to increase the amount and difficulty of subject matter preparation would probably worsen the plight of the culturally deprived child and add new difficulties to the school day of the slow learner. The culturally deprived children and the slow learners in any group will not be helped by larger doses of what is now destroying their faith in themselves. They need understanding and careful study on the part of teachers who have the psychological, sociological and human relations understandings, and skills that are necessary for such work.[10]

The interest of the federal government in poverty programs, urban education and urban renewal, model cities, minority groups and a multitude of welfare and community improvement programs is witness to a vast need and an educational vacuum. Presumably, the programs also reflect the will of the people. Critics largely ignore the educational implication of such programs

[8] *Ibid.*, p. 8.

[9] H. C. Rickover. *Education and Freedom.* E. P. Dutton & Co., Inc., New York, 1959, p. 204.

[10] Ernest O. Melby. "Roots of Criticism." *Childhood Education,* 40: 119, November, 1963.

and the crucial needs which they indicate. It is a bold assertion, but I believe, nevertheless, a true one, that the large scale curriculum projects so handsomely funded are largely irrelevant for the group of students included in the target families for these programs. It is axiomatic that men who cannot walk can scarcely run! But these are not the only children being cheated. There are others! Here is a comment from a parent of a gifted child.

I might be able to assemble for you a supportive panel of bright, rather wan-looking graduating seniors, several of whom (my eldest daughter, for example) are either suffering from or recovering from mononucleosis; who are all about '98th percentiles' and National Honor Society members, 'deadened' (in their own words); and upon whom the ardor with which school administrators have sought to prepare them for college has had almost opposite effect from the one it was expected to have. They don't really want to go to college at all, for a year or so. I, at least, among their parents would be on hand to champion their feelings that it would be nice to read a book because one wanted to, to meet people who were unlike one's self, to have a chance to 'think about things' (including college), and to go bicycling on spring afternoons.[11]

Here is a tape recorded comment from a conscientious student.

I don't think there's anything physically wrong with me, but I just go through life feeling terribly tired. I usually sleep through the first period of the day. When I get home, I want to lie down and go to sleep. In the morning it takes a long time for my father to get me up. I haven't been sick; I've only been nervous at certain times.

I've been able to handle the pressures quite well, except for the fatigue that's involved. After studying, I feel tired because I've been reading over and over again the facts I'm likely to be tested on.

I go through times when I seem to collapse. These are not necessarily at points of stress, but after them. There's so much presure, it seems, that it builds up to a point at which you have to let off steam. So I get nervous twitches, or my hands start shaking, or I start arguing with my friends.

Aside from fatigue, I have periodic breakdowns—not real breakdowns, but there are times when I feel I'm not going to be anything in this world. Then I give my mother a hard time. The next morning I'll be my usual self. . . . I think all this is a result of a fatigue that culminates in this period of self-destruction and despair; but you get over it and start again in the same routine.[12]

Here is another such student comment.

Some of my courses have been like not only freshman courses in college but even like senior courses in college. Of course, this varies greatly. What colleges are we talking about? And what teachers in what high schools are we referring to?

In Spanish, we're now using a book that is used by sophomores in college, and our teacher is teaching us from notes she used as a sophomore in college.

College seems to have moved down to high school, especially in math and science. In my sophomore year we had a fat notebook full of notes the teacher of bio!ogy had taken during a summer institute, plus our regular textbook and a supplementary book that said inside it, 'This book is for seniors in college who are working in their field of concentration.'[13]

What is the legacy of the generation of critics? There can be absolutely no doubt that the effect of the critics has been profound. But has change been progress? A cynic could certainly make a case for the fact that education is in a worse state today than it was 10 years ago. The following specifics could be cited.

1. The crime rate among juveniles mounts steadily.
2. There is more and more evidence of the alienation of youth—drug addiction, "hippyism," vandalism, sexual promiscuity and venereal disease.
3. There are increasing suicide rates and other evidences of mental illness among students.
4. There are mounting teacher shortages, evidences of teacher unrest and questionable professional actions.
5. There is evidence of increasing psychosomatic disorders among students.

These facts evidently do not relate solely to the schools but it would be difficult to refute the argument of substantial associa-

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[11] Reported in: *Children Under Pressure.* ed. by Ronald C. Doll and Robert S. Fleming. Charles E. Merrill Books, Inc., Columbus, Ohio, 1966, pp. 6–7.

[12] *Ibid.*, p. 9.

[13] *Ibid.*, p. 10.

tion. The critics have influenced educational practices in varying degrees. Some of their adverse effects on the schools can be identified as follows:

1. Forcing unsuitable content into the school curriculum and removal or de-emphasis of needed courses not "academically respectable."
2. Advocating methods and content which cannot be justified or supported on educational, psychological or sociological grounds.
3. Setting unreasonable standards for attainment.
4. Promoting policies which ignore the real needs of students and which result in pressures detrimental to the wholesome development of adolescents.
5. Intimidation of teachers, administrators, and school boards.
6. Down-grading of essential professional training for teachers.

No doubt the list could be considerably expanded but it is sufficiently representative. The truth is that we have had far too much educational leadership usurped by the critics, and as a group, and by not standing their ground, educators have effectively acquiesced in the usurpation. It is a time for a professional renaissance and reassertion of professional leadership. It is time to stay the tide of "leadership by criticism." Educational reform is needed but it should not be illegitimate critics that inspire and direct it. Educators and school boards should once again take over the leadership responsibility that is rightfully theirs and shape a program which is truly fitted to students and their times.

SUMMARY

If we are going to challenge the critics we are going to have to become activists. Many of the critics cannot be answered with facts because they are immune to the serum. But we can label a lie as a lie at every opportunity. Through our professional associations we may even find it necessary to seek political, economic and legal reprisals. It is unfortunate that the critics have been able to convince the editors of respected periodicals, sometimes even our own professional journals, to print unjustified and irresponsible attacks on education. Personal experience with one of the best literary magazines in the country convinces me that a reasoned rebuttal to such critics does not stand much chance of getting set in type. It is obvious that other measures are required to cope with such examples of remunerative but irresponsible journalism.

In summary, the wave of criticism has had an adverse effect on the lives of many children and adolescents. It has tended to de-emphasize the individual. Clearly, society and the schools are already too depersonalized and we are all too much in danger of becoming a cipher or a series of ciphers on a battery of computers. The fact that the schools have been so complaisant in responding to criticism is probably a sign of their weakness in the face of the hot winds of a public opinion shaped and formed by inaccurate, unsupportable and dangerous criticisms. The fate of a generation of children is to a considerable extent being influenced by critics whose concepts of education are erroneous and often long outdated. There are signs that the public is having some second thoughts about the "great reformation" inspired by critics. If educators are worth their salt, they will rise up and reassert their leadership and once more place the process of education on sound educational and psychological grounds. The tide and wind are favorable and a generation of children will be the grateful beneficiaries.

DINOSAURS AND DODO BIRDS IN HIGHER EDUCATION: THE EXTINCTION OF INSTRUCTION *

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During prehistoric time the dinosaur and dodo bird disappeared from the earth. The conditions which brought about their extinction are not well established. Today, in the realm of higher education, instruction seems to be facing extinction. There is considerable evidence to support this contention, including the disappearance of major professors from the classrooms of basic courses, or, all too frequently, from all teaching, and the reports from college students who rate their college instruction, whether it was done by teaching assistants or major professors, at levels quite inferior to those to which they were exposed in high school. While the forces at work in prehistoric times could not be stayed, this is hardly the case for higher education today. The time for concern, including an assessment of causes and the application of corrective measures, is at hand.

It must be understood from the start that this paper is not the result of research; but rather, it is a synthesis of the thinking and statements of others who have considered this topic. Further, no claims are made that all the possible causes of what appears to be a weakening of the instructional function of professors have been located or are included here. No judgments of the relative merits of the generally accepted functions of a college faculty member are intended.

This is not a topic new to the realm of higher education. Concern has been expressed in such periodicals as *Educational Record* and the proceedings of the annual conferences on higher education of the Association for Higher Education, and in the popular press, such as *Time*. It has been discussed in meetings of the American Council on Education and by innumerable college students.

Kinnane [4], in an analysis of student opinions, found that 52 per cent of those polled felt the professor to be essentially a teacher. She suggested that the professors might be surprised at the low esteem which students held for the faculty function of writing. She felt that students sensed that there was a discrepancy between the activities which professors felt contributed most to their own advancement and those for the benefit of students.

Students do know good teaching, and as an advisor, I have had direct and indirect opportunities to hear their expressed opinions. At present, the secondary teachers rate much higher than their college counterparts at professorial or teaching assistant levels and all ranks between with respect to teaching competence.

The following are illustrative of the existence of a real problem. Some students may never be taught by a major professor during their undergraduate years on campus. On some campuses the student is unlikely to see instruction from one higher in rank than teaching assistant during their first two years of mathematics courses. The same may very likely be true for freshmen English students. Basic courses are being taught more frequently by way of closed-circuit television systems. While this instruction may be generally satisfactory and in some cases may have features that are superior to those found in direct contact teaching, the professor of such a course is not to be envied for he has no feedback from a class of students to indicate to him the adequacy of his pacing, his mode of instruction and the students' comprehension, or lack of it.

* This paper was derived from the vice-presidential address, Section Q, of the American Association for the Advancement of Science, presented at the Washington, D.C. convention, December 29, 1966.

The perpetuation of a marking system which has the same fixed passing mark and subsequent predetermined per cent of failures as used in the past in spite of rising requirements for college admission are indicative of testing and marking practices that are inadequate, inappropriate, and unjust. I heard of a professor who disclaimed any responsibility for students' inability to understand a course being taught because they were unable to recognize salient points of a lecture by saying, "I can't help it if I'm a poor lecturer." I have also heard students complain about teaching assistants and instructors who had so much trouble with their English as to be unintelligible.

It is easy and unjust to make snap judgments which could be stated as rationalizations for examples such as these. But such student statements about their teachers as: "they can't be bothered with teaching; they are too busy doing other things; they don't know what good teaching is; they are prepared to do other things", need some amplification. Instead let us examine in greater depth some possible reasons for the seeming plight of instruction in higher education.

A first and obvious reason is the dilution of instruction brought about by the increase in the number of college students, an increase which is more rapid than the increase in the number of teachers. Over the next 5–10 years it is likely that there will be teachers for all students, but the contacts of these teachers will be with the numbers of students multiplied by tens compared with present numbers.

The teaching function of college and university faculties continues to be diluted by the addition of other staff responsibilities. No college or university recognizes teaching as its only function. In addition to his teaching, each professor is expected to assume responsibility for advancing knowledge through research, provide service functions on and off the campus, and accept the functions of campus citizenship. Each of these is important and problems arise only when it is assumed that all these functions must be carried out by each individual or that one of these is of greater merit than the teaching as a basis for promotion and salary increase.

John Gustad [3] writing in *Educational Record,* said ". . . The extent of agreement between faculty members and administrators with regard to what faculty members do and what they would like to do is distressingly close to zero. The area causing greatest concern . . . is the identification and rewarding of good teaching."

Brown [2] sought answers to the question: What are the bases for obtaining salary increases and promotions? Obviously, market pressure was a matter of great importance between disciplines. On the other hand, within the disciplinary specialties he found that researchers moved forward more rapidly than teaching scholars. Average salaries were lowest for those with no publications ($7,800), next for those with at least one but fewer than ten publications over the previous five years ($10,500), and highest ($12,700) for those with ten or more publications or one book in the previous five years. The latter group of publishers attained their full professorships at an average age six years younger than the nonpublishers, and a greater per cent had senior academic rank, 48 per cent versus 7 per cent.

It can be seen from such as this that while many institutions indicate that effective teaching is the primary function of the institution, this has not been associated with corresponding recognition and rewards. In part, at least, this is related to the nature of the preparation of the professors and their administrators, most of whom have come from professional ranks. This involves strong preparation in the subject matter of the discipline and for engaging in research. This preparation is the kind required for the Doctor of Philosophy degree, the degree of most graduate schools, and a degree generally associated with the preparation of scholars. To assume that persons holding such degrees are necessarily adequately prepared to carry out the responsibility of teaching is not acceptable. Still,

having the degree is an asset to those who would teach.

An examination of the salaries of college faculty members for 1965–1966 would reveal the value that the doctorate had for them [7]. For example, for full professors in 66 institutions the median annual salary difference for persons entering the rank with and without this degree was $588 in public and $600 in nonpublic institutions. The median annual difference in annual salary for full professors was $720 and $772 in the same types of institutions. The differentials were not as great at lower ranks.

What is known about the people who earn the Ph.D. degree? Allison [1], reported that half the graduate students came from well-to-do families. About half the students in physics and botany came from wealthy families; only 40 per cent of the earth scientists and chemists came from wealthy families. In a study of 3400 graduate students, only a few claimed to want to make a lot of money; all expressed an interest in the opportunity to do creative original work. A preference for working with people (in my estimation, a requisite to good teaching) shared by physicians, lawyers, and business students was not shared by mathematicians, chemists, engineers, and physicists. An image of themselves as conventional people was rejected by more than half the chemists, mathematicians, engineers, artists, and physicists, in increasing order of intensity. These findings cannot be interpreted as being strong motivations to enter graduate schools for the purpose of preparing for teaching. Of course, it might be assumed that the teaching force comes from the minority of graduate students who were also part of the study population. Yet, this hardly seems reasonable in the light of the other subjective evidence provided so far.

The narrow specialization and research emphasis of the Ph.D. degree program places serious restrictions on the versatility of the possessor of the degree when he attains a faculty position. He obviously will want to do what he feels most capable of doing, and being honest, may well admit to his shortcomings and participate in any other activities with reluctance. He will look to colleagues who hold the same point of view for approval and understanding of what he does and finds important. He will identify with research rather than with teaching. He may well join the many who assume that those who teach undergraduates willingly are immature, lacking in knowledge of the discipline, unable to carry out research, or a combination of these.

Because his Ph.D. degree is strongly identified with the discipline in which it was earned, the holder of the degree also identifies with the discipline. This has led to the practice of leaving the evaluation of a faculty to representatives and organizations from the discipline. To be sure, this has merit, for these evaluators recognize adequate preparation in the discipline better than anyone else. However, their criteria for evaluation of the professor's contribution and potential are most likely to be in terms of research ability, output, and writing which can easily be ascertained, and not in terms of teaching ability. Administrators have allowed the opportunity and responsibility for evaluation of instruction to pass to others by default. They have turned the responsibility over to those who have been similarly trained and have the same point of view about the importance of the various functions a university or college and its professors. One institution reported that teaching and research were tied as the prime factors considered in promoting faculty members and that these were followed closely by publications and supervision of graduate students. In the same institution, the graduate dean reviewed, with the discretion to reject, all appointments to tenure rank. This helped ". . . maintain high quality of graduate instruction and graduate leadership in research." There has been little done to overcome this kind of situation. Attempts at the evaluation of teaching effectiveness have been relatively few and feeble.

For many people teaching has come to

have a negative connotation. Prospective faculty members bargain for research facilities and it is not unlikely that the chance *not to teach* some courses (probably undergraduate and especially at the freshmen level.) may figure prominently in their selection of a position. It has been said that teaching has become the least fashionable of the activities engaged in by college professors.

Whether it is true or not, professors do not believe that teaching rather than research pays off in promotions and salary increases. In fact, to paraphrase Newburn [5], the young professor takes a pragmatic approach and says that if they want publication they will get it, and in quantity too; there is time enough for more substantial and quality efforts upon reaching the top rank. They may have some pangs of conscience and feelings of regret, but they are willing to adapt to circumstances.

The highly specialized nature of research today requires that it be essentially a full time operation. Funds are available in considerable amounts and these cannot be resisted by the institutions of higher education because they pay salaries; purchase facilities and equipment; give "overhead" expense funds, and add to the status of both the institution and the researcher. The result has been to put pressure on the teacher-professor to write proposals (a highly time-consuming activity); administer a staff and funds when the grant comes, and report and publish the results. The consequence of the acceptance of these new activities is that the teaching load is reduced, or at least that the teaching effort is seriously diluted for lack of time for preparation.

In many instances research emphasis is rationalized by such unresearched hypotheses as: staff members must do research to keep up with new ideas to pass along to their students; scholarship, including research facility and activity, makes for effective teaching; and the findings of such research are pertinent to the content of the courses the professor teaches. While all these hypotheses may someday be supported at the graduate level, they are unlikely to be supported at the undergraduate level, especially introductory courses. It must be noted here that this does not deny the university's function of being producer of knowledge through research. It could be suggested however, that the research function as well as the teaching function might be enhanced by having these tasks carried out by persons specially trained and highly motivated in one or the other of these functions rather than by a person expected to do both.

Any consideration of collegiate teaching problems must include an examination of the preparation and role of the junior members of a staff; the teaching assistants, teaching associates, and instructors. When professors spend increasing amounts of time on activities other than teaching, more responsibility is delegated to persons at these lower levels. These faculty members are usually graduate students. Of the Woodrow Wilson Scholars compared by Kinnane [4], students who had selected college teaching as a career, believed that the best entry into the profession was to go for the doctorate immediately upon completion of their baccalaureate degree. It is of more than passing interest to note that only 2 percent of the graduate students had prepared for high school teaching in their initial degree program.

The teaching assistant enters instructional activities in colleges armed with little more than the knowledge he obtained in his previous degree work and his memories of the teaching to which he was exposed. His knowledge of the courses he is to teach, especially if he is new to the campus, may be little more than a catalogue description, a course outline and/or a textbook. That this is apparent to college students is indicated by this quotation from the editorial page of a college newspaper [6].

> It is no secret that TA's at the University usually are atrocious instructors. They have no idea what their responsibilities as instructors are, they can't communicate their concepts to their students, they are inadequately prepared for lectures or discussion, they are inaccessible outside of the classroom, they are sloppy and unfair in

grading exams and papers. In short, most of them just don't give a hoot for the students. This situation is not entirely the fault of the TA's. There is hardly a department or school at the University which provides more than token orientation for its TA's. This problem is not limited to the University, of course, but is found in almost every school employing TA's as instructors."

The methods employed in preparing and training a new teaching assistant or instructor include such activities as pre-course orientation, weekly meetings, conferences with major professors and evaluation visits by the senior staff. Student evaluations are rarely used. One chairman of a department using large numbers of teaching assistants admitted that the College of Education at his institution played no part in the training programs, saying "We are interested in specifics, not theories." * From this statement one could not be certain as to whether this was indictment of the department or of that College of Education. However, from the same college campus another individual who trained teaching assistants as part of his assignment said that methods courses from the College of Education ". . . put you at a distinct advantage." Too many training programs are little more than the blind leading the blind.

Additional comments from students indicate other pertinent concerns regarding the problems associated with the assignment of teaching assistants to ever increasing numbers of classes and courses. Students have been reported to say:

"There is no consideration of teaching ability; departments just want to fill vacancies."

"Make them schedule more office hours; teach them how to initiate student response; let students evaluate TA's so they can get some feedback; make TA's prepare better for class; change their attitude."

While most the students surveyed at one college felt that the teaching assistants often knew their material well and gave more time to their students than the professors could or would give, one stated, "Mine seemed too interested in pursuing their doctoral studies and not interested in teaching." From the same college an associate professor said, "If there is any error that our TA's make, it is that they take too much time for teaching and neglect their doctoral studies." This latter statement points up a conflict of interest which becomes a serious matter for the graduate student who must make the decisions about where his effort is to be concentrated, a decision which he may well have to make again if he chooses a career in teaching. It also is a serious matter for the undergraduate student who is being taught by the graduate student who chooses to emphasize his academic study, or his research rather than his teaching responsibilities.

Not only do the research and publication commitments impose a serious threat to teaching functions, but service functions including those involved in discharged campus citizenship responsibilities may have a similar effect. Let us consider first the accelerating concern with the improvement of all levels of education abroad. Please note that the writer is not against such concern, nor the attempts to do something about them. Neither does he question the motives of those who would assist in this desirable work. However, it has become fashionable to seek and obtain appointments to carry out foreign projects. These appointments are almost as effective as research endeavors and the obtaining of funds for research and innovation in producing the visibility so essential in seeking promotions. There has resulted a reduction of campus manpower, the introduction of more teaching assistants, and frequent postponement of campus projects and degree-progress of graduate students caught in the operation.

Consultantships of many varieties are becoming more numerous, especially those associated with the spending of grants of government and foundation funds for research and innovation, at all educational levels.

* It seems best that the authorship and institutions involved remain unidentified though documentation can be supplied.

State departments of education, national and local academic organizations, as well as campus committees, make their demands. Illustrative of some of these demands are curriculum revision and development activities. Numerous college professors were engaged in National Science Foundation elementary and secondary school curriculum development. A year's absence from the campus scene was almost normal. We can assume without expecting serious contradiction that these efforts were sincerely given and were effective. It might be suggested now that those who were effective in these past efforts for secondary education return to their campuses to perform these functions for higher education. The efforts are sorely needed.

Although the assessment of the situation would lead to feelings of concern on the part of many people; there are those who feel that the worst is over and that new views and efforts to alleviate the conditions of the past are in operation. There are those who feel that a flight from teaching is not a problem; but rather, that the problem of real concern is the heavy teaching loads imposed upon faculties. From any standpoint, it is certain that looking in the other direction will not cause the problem to go away. Prior to other moves, there must be a careful examination, including research efforts, of some deeply ingrained beliefs and practices. The results of the examination should provide suggestions for the next moves.

Perhaps the most difficult of the beliefs to overcome on the college scene is that which allows for the maintenance of the present state of things because "it was always thus." One never ceases to be surprised at how easily the Young Turks become the Old Guard. Careful scrutiny must be given to the notions that:

> Effective teaching cannot be evaluated by either faculty or students.
>
> Specialization in the narrow sense of the Ph.D. degree is adequate preparation for teaching.
>
> All professors want to do research more than anything else.
>
> Good teachers were born with this capability.
>
> The teaching assistant, without training, is an effective teacher.
>
> Research and teaching functions must be carried on by the same person.
>
> Research facility and teaching competence are highly correlated.

Part of the examination and research must consist of long term projects and should involve: the separation of the teaching, service and research functions; the design and implementation of degree patterns other than the Ph.D. for the preparation of college teachers, especially teachers of lower division undergraduate courses; and the development and trial of programs for the preparation of teaching associates and instructors.

Such is one professor's assessment of the current situation. Fortunately for higher education, adjustment to the conditions which are operating to imperil instruction will be made. Those who are involved—professors, administrators, junior faculty and students—are sensitive, intelligent, and rational. They recognize the problems and have the means for solution at their disposal, and hopefully they will not hesitate to use them.

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PRE-1960 CONTRIBUTIONS TO SCIENCE EDUCATION *

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When scientists came out of their laboratories some ten years ago to examine science education as it was practiced in the schools, they registered grave concern about what they found. Some became quite vociferous in condemning science courses of study, science textbooks, and those who were responsible for producing them. Little, if anything, of the old science courses was found to be acceptable and the battle cry for a revolution in science education spread throughout the scientific community.

Implicit in the revolutionary movement was the idea that nothing of any consequence had previously taken place in science education. The revolutionaries were to begin from scratch and create courses that had integrity in terms of the scientists' concepts of their respective disciplines. Further, they were to lose no time in producing innovations and getting them introduced into the schools.

The consequences of the various course improvement projects in secondary school science are well known to most of us. They have had considerable impact upon science education in the schools. Because of the national and international attention that the course improvement projects have received, it is not easy to accept them as mere incidents in an ongoing, continuous effort to improve science teaching in the schools. But, there have been other incidents and there will be an infinite number of future incidents contributing to the evolution of science education. This statement, obviously, is based upon the assumption that science will not, at some future time, become extinct in whatever educational enterprises emerge.

In the opinion of the person who planned this program, it seemed desirable that we do not lose sight of the fact that we have a heritage in science education, and that it may not be necessary for each generation of science educators to rediscover ideas formerly demonstrated to have been tenable. If, in fact, it is necessary to rediscover the ideas before one becomes convinced of them, then he should recognize that he is reconfirming the idea rather than making an original discovery.

In a sense, I have been asked to play the role of a "flew-flew bird." The "flew-flew" is an unusual avian creature that flies backward. Many ornithologists have attempted to explain its unorthodox behavior. One theory is that it doesn't like the wind blowing in its eyes. But the theory that is most widely accepted is that the "flew-flew bird" has no concern about where it is going, but only about where it has been.

Lest I leave the impression that there were no "flew-flew bird" tendencies in any of the course improvement projects, I must hasten to point out that the Biological Science Curriculum Study had one of its staff flying backwards concurrently with others who were flying forward in producing course materials. I refer to the excellent work by Dr. Paul De H. Hurd [1] in his analytical review of biological education from 1890 to 1960. In addition I refer to the feasibility study conducted in 1961, under the leadership of John R. Mayor. The study was carried out to gain perspective before the AAAS Commission on Science Education launched its well known elementary science project: *Science: A Process Approach.* [2] Also, I refer to the scholarly work that Herbert Smith [3] accomplished for the Commission in his review of the research related to science instruction in the elementary and junior high school.

* Invited address, Section Q (Education) of the American Association for the Advancement of Science, New York City, December 27, 1967.

Another publication, in this category, that has come to my attention is the report prepared by the National Science Foundation in 1965 for the Eighty-ninth Congress. [4] This report gives a historical perspective to the current efforts to improve science education by presenting a relatively concise history of science education in the schools of the United States.

Contributions to science education such as I wish to consider in this paper have come from two sources. They have come from a variety of authoritative reports prepared from time to time by responsible committees and commissions. Hurd reviewed 75 such reports in his study of developments in biological education.

Some contributions to science education also have come from the reported research in science teaching. Over the years a number of reviews of research have been published. The most classical of these were the three volumes in which Francis D. Curtis prepared digests of the significant research in science education that had been conducted prior to 1937. [5] Some reviewers have attempted to interpret research findings and infer implications from them for science teaching. These publications have been prepared primarily for teachers. In 1956 under the sponsorship of the American Educational Research Association and the Department of Classroom Teachers of the National Education Association, I prepared such a document on high school science teaching. [6] Gerald S. Craig prepared a companion document on what the research says about teaching science in the elementary schools. [7] It was published in 1957. These were attempts to sift from the research findings those that appeared to be most tenable and to indicate how the science teacher should use them in evaluating and modifying his teaching. My guess is that very few, if any, teachers ever used the documents for these purposes.

Here is a word of caution that I would like to pass on to those who would read this paper. The ideas which one selects from either the authoritative reports or the research, as contributions to science education are, to a large extent, determined by his biases. Another person, with another bias system, might arrive at different ideas than those I have identified. The name of the game is science education and practically everyone who plays it soon becomes a "pro."

I have selected only a few authoritative reports to deal with in this paper. The ones I have selected illustrate some of the contributions that I believe are important for science educators to give attention to in these times.

The first report that I choose to mention was published in 1920. It was produced by a committee of 47 scientists, science educators, and science teachers under the leadership of Otis W. Caldwell. [8] The report was based upon a critical analysis of science education in the secondary schools. The frame of reference for the analysis was the classical seven cardinal principles of education. These had been evolved to give a comprehensible and defensible direction to secondary education. In its report the committee demonstrated how science teaching should be reconstructed and managed in order that both the concepts and methods of science would make maximum contributions to the cardinal principles or purposes. The efforts of the Caldwell science committee, and similar committees who were working concurrently on other secondary school subjects, had an organismic quality in terms of the total educational enterprise that seems to be lacking today.

In 1932, Wilbur L. Beauchamp was commissioned to assess science teaching in the secondary schools as a part of a comprehensive study of secondary education in this country. [9] He approached the assignment by investigating courses of study from a sample of secondary schools. Among other things he examined the objectives as stated in their courses of study. He found that the objectives, as listed, covered a broad

range of pious aspirations for science teaching.

Subsequently Beauchamp visited schools from his sample to determine how well classroom practices reflected emphasis upon such commonly stated objectives as "to develop critical thinking." He found that science teachers in general did not understand how this or many other objectives could be made operational in their teaching. Obourn [10] in a study of the practices of science teachers conducted 18 years later found much the same situation. It is my understanding that a similar situation has been confronted by those who are responsible for implementing the "investigatory approach" advocated by the BSCS modern biologies. In light of the above, no one should be surprised that any effort at science curriculum development ultimately will be faced with the monumental task of re-educating teachers before the new curriculum becomes operational in the classroom. The problems faced in educating and/or re-educating teachers eclipses those involved in developing the new curricula.

The authoritative report that has had the most far-reaching effect upon science education over the longest period of time was the Thirty-first Yearbook of the National Society for the Study of Education. [11] This document was prepared by a committee consisting of recognized leaders in science education of that time. It was a comprehensive effort to develop a philosophical and psychological rationale for a science program beginning in the elementary school and extending through the secondary school. Until the publication of *Theory into Action,* [12] the Thirty-first Yearbook had been one of the most distinguished attempts to produce a rationale for curriculum development in science for the schools. The yearbook committee defined three major purposes toward which science teaching at every level should be directed: (1) competence in methods of investigating in science; (2) development of scientific attitudes; and, (3) understanding of selected major generalizations. It also indicated generally how elementary school science, junior high school science, and senior high school science should be organized and administered to sustain continuing advancement of students toward the achievement of these purposes.

To a large extent the dilemma, presently faced by public schools in deciding if they should adopt the "new" science courses, which ones they should adopt, and how the "new" courses should be accommodated in a K–12 science sequence, is accounted for by the fact that there is presently no commonly accepted philosophical and psychological rationale comparable to that formulated by the Thirty-first Yearbook committee. *Theory into Action* represents a significant effort to develop such a rationale. However, the flak of controversy generated by its publication indicates that the rationale it advances is far from being commonly accepted.

In science education today, it would appear that we are in a state of competitive fragmentation comparable in many respects to what the Thirty-first Yearbook committee considered the state of affairs to be in 1930:

"A principle that seems to have full acceptance among educators is that education should be a continuous process that begins with the learning experiences of early childhood and continues throughout the period of life. The aim of the school is to furnish elements of enrichment to this program of continuous education, but in the selection of materials for the teaching of science this guiding principle has not had full recognition. Uncoordinated and often opposing agencies have contributed instructional material. . . . Workers in secondary education have witnessed a good deal of rivalry between specialists in these fields as each group of specialists has sought to strengthen the position held by their subject. As a result, much of the activity in science education has been in support of subjects, and the questions of educational values for children in the elementary and

secondary schools has not been given the prominence that it deserves. Again, there has been an evident lack of integration between the work of the elementary and secondary schools, and within the secondary school there has been a lack of integration between the work in the special sciences."

Is this point of view regarding the continuous nature of education still a valid one? If so, should we not be giving it greater attention? Whose responsibility should it be?

In 1938, the Commission on Secondary School Curriculum of the Progressive Education Association, published a report prepared by its science committee. [13] In the report, the committee presented a philosophical rationale for a science curriculum, a theory of science teaching, and a number of examples of how the theory might be implemented in the schools. This report was used as a basis for curriculum planning in thirty pilot secondary schools over a period of about eight years. Its contribution to science education should not be judged in terms of any long-term impact upon science teaching but rather in terms of the pronounced effect that it had on the thinking of those who were actively involved in science education at that time. Its primary concern was the individual and ways in which science in the schools should contribute to his personal and social development in a democratic society. If, as Smith [3] points out, there is a difference between the ways in which the educator and the scientist view science teaching today the basis for it probably lies here.

There are at least two other authoritative reports: the Forty-sixth and the Fifty-ninth Yearbooks of the National Society for the Study of Education that have, in various ways, made their contributions to science education. [14,15] Both of these reports were prepared in times more comparable with the present and reflect the growing concern about the roles of science in our society.

In the authoritative literature in science education for 30 years prior to 1960 there has been a persistence of commitment to the points of view that:

1. Science is an imperative component of our culture and, therefore, should play a prominent role in the education of all American youth.

2. "Education is a continuous process that begins with the learning experiences of early childhood and continues throughout life." Science education in the schools should be a continuous, developmental process from kindergarten through grade twelve.

3. Before curriculum development in science and science teaching can become rational processes, the objectives to be achieved must be defined, either implicitly or explicitly. Objectives should derive from a rationale having scientific, sociological, philosophical and psychological dimensions. Both the rationale and the objectives must be communicable to the teacher practitioner in ways that will insure that the objectives will become operational in the classroom.

4. In defining the objectives of science teaching both the conceptual and procedural characteristics of the scientific enterprise must be considered.

5. We learn by doing only to the extent that we are *thinking* about what we are doing. To identify and define the processes involved in "scientific thinking" will help teachers make it operative in the classroom.

6. There is a persistent need for quality research in science education that will: test the validity of objectives; investigate the processes involved in learning science; investigate teaching techniques by which learning may be enhanced; and produce valid instruments for assessing achievement in science.

Finally, I would like to comment upon contributions to science education from the research in science teaching as reported in the literature prior to 1960. The research effort in science teaching has been confined primarily to the present century. None of the research reported in Francis D. Cur-

tis' [5] first digest was published before 1900. In Smith's [3] bibliography, consisting of 87 references, only four were published prior to 1900 and none of the four dealt with research in science teaching. For practical purposes the research in science teaching prior to 1960 was that produced during the lifetime of one generation of science educators. The quality of it has not always been good. It has been spotty and superficial in many instances. However, its quality has improved over the years.

From the research findings in science teaching, one can make certain inferences with considerable certainty.

1. Children can conceptualize at various levels of sophistication depending upon their maturational development and the nature of their experiences with selected natural phenomena. This conclusion has been well supported for some time by the research literature on science teaching. To rediscover it is a thrilling experience as attested to by Jerome S. Bruner in a report of his recent experiences in working with elementary school children. [16]

2. Students can be taught the attitudes of critical thinking and methods of investigation which enhance their interest in, and facility for, learning science. However, the methods of teaching must be designed towards these ends. In science we generally accomplish that for which we teach.

3. In comparative studies the methods of teaching science that have been found to be most effective in developing science concepts and facility in using the processes of investigation are those that are characterized by student participation or involvement. Knowledge of this fact and commitment to its validity motivated many science educators to advocate drastic changes in the methods of teaching science long before the recent revolution in science education.

4. Failure to find such terms as "discovery" and "process" in the earlier literature on research in science teaching does not mean that their referents have not been investigated. In fact, they have. Such concepts as "scientific thinking," "problem solving," "inductive method," and the like have much in common with the equally vague concepts currently referred to as "discovery" and "process." This situation is only one example of the semantic problems which make the interpretation, evaluation, and replication of research in science teaching so extremely difficult. Through the Council for Advancement of Research in Science Education and the ERIC Center in Science Education, an attempt is being made to develop an epistemology for the domain of science education and a thesaurus of concepts with which it deals. If this can be done eventually, it will constitute a major contribution to the advancement of research in science education.

5. Many efforts have been made to develop testing instruments to be used in assessing the achievement of students with respect to concept development and the intangible outcomes of science teaching having to do with critical thinking and problem-solving. Very few of them have come off as being generally acceptable. However, I believe that there is buried in this mass of literature material that may have some significant reward for those who would mine it. It is clear from the research that what is needed most to advance our knowledge of science teaching are valid assessment instruments. Before we can hope to make any demonstrable progress in the improvement of science teaching in the schools much more enlightened efforts have to be directed toward the development of appropriate tests.

Although science education is an applied field depending upon certain basic knowledge from such disciplines as philosophy, psychology, and sociology, it does represent an emerging domain of effort that is becoming increasingly important in the future development of education in this country. Although its heritage is spotty and shortline, we can ill afford to ignore or deny it.

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HIGH SCHOOL CHEMISTRY RESEARCH SUPPORT PROGRAM SPURS ADVANCED COURSES

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Two years ago Chemical Education Projects of the Philadelphia A. C. S. Section instituted a research grant program for high school chemistry teachers and their students. During the first year eleven research projects were funded. Each project received $250 to $900 support. The money was given to purchase supplies and nominal equipment needed. A small amount of money also was awarded to each teacher as a token honorarium. Each proposal submitted indicated that one or more high school students would be involved with the teacher in pursuing the research. The monetary awards, while relatively small by industrial standards, already have influenced not only the chemistry programs of several of the participating schools but also their science programs in general. Describing one school and the effect the research support

program has had on its chemistry program and science programs in general may be of help in stimulating interest in developing comparable research support projects.

Germantown Academy received one of the eleven grants. Two years ago the Academy moved from its old location in Germantown, Pennsylvania, to a new campus in Fort Washington, Pennsylvania. Through the help of the Robert McNeil Jr. Foundation a science wing was designed to include science laboratories, classrooms, and space for modest faculty-student research. The decision to include the research areas was influenced by the literature describing the Philadelphia Section's Chemical Education Project's Research Support Program.

At the time the new building was completed, the science curriculum included a traditional sequence of courses: general science, biology, chemistry, physics. The Chemical Education Materials Study (CHEMS) program materials were being used in the first level chemistry classes. At that time there was no advanced chemistry course as part of the science curriculum, nor were there any funds available for this kind of expansion of the science program.

In 1966 the School, through Walter Hoesel, chemistry instructor, applied for and received one of the A. C. S. research awards. He proposed to have two students, under his direction, pursue two projects on a before school- after school- free period basis. Kenneth Peters, a senior, would study critical concentrations for the precipitation of calcium copper acetate. In this study it was hoped to determine the exact ratio of reactants at which calcium copper II acetate hexahydrate will form rather than copper II acetate dihydrate, and whether the ratio of salts needed is influenced by temperature. Fred Williams, also a senior student, would investigate the effect of sodium bromate crystals on the rotation plane of polarized light. In this study it was proposed to prepare pure crystals of sodium bromate, to construct and calibrate a polarimeter, and to see how these crystals affected light of varying wavelengths. These two students spent the year on their respective projects, and a report of the results was submitted to the local Section Committee responsible for the research award program. There is now the opportunity to present a paper of the findings at an A. C. S. Middle Atlantic Regional Meeting.

The research activity was so successful that the administrators at Germantown Academy decided to institute a formal second level course in chemistry, as well as one in biology and one in physics, for those students interested in advanced work in science. These three courses are to include some content at an advanced level; but more important, students enrolled in these courses are able to pursue their own research under guidance. Grades seven through twelve at the Academy enroll 440 students. Normally such a small enrollment would preclude offering second level courses of any type. Here the relatively small student body insures that second level courses will have no more than about eight students enrolled in them, making it possible for each student to receive reasonable teacher guidance. By use of a rotating class scheduling system students in these advanced classes are insured larger blocks of uninterrupted time in which to develop their projects. In addition, the laboratories and research areas are open for their use during after school hours.

The experience at Germantown Academy indicates that a small research grant can act to catalyze fruitful changes in the chemistry and science curriculum. Hopefully other schools throughout the country can follow this lead.

A DEMONSTRATION OF THE ROLE OF SCIENCE IN THE PROGRAMS OF EDUCATIONALLY DEPRIVED CHILDREN IN GRADES 7–9 *

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PURPOSES AND OBJECTIVES

The purposes of this pilot project are (1) to demonstrate the use of science as a tool in encouraging educationally disadvantaged youth to active participation in learning; (2) to develop science materials and approaches uniquely suited to challenge the educationally disadvantaged; (3) to assess the effectiveness of the program in terms of changes of behavior of the pupils in the experimental classroom; and (4) to refine procedures, techniques and materials for a more extensive and more carefully controlled investigation.

IDENTIFICATION OF STUDENT POPULATION

The identification of the underachieving population and the random assignment of members of this population to experimental and control classes were attained in the following manner:

1. All pupils enrolled in science classes were identified and pertinent data collected.
2. Pupils having a cumulative grade point less than 2.00 (computed on a 4.00 point scale where A=4, B=3, C=2, D=1, E=0) were identified. Only grades in English, math, social studies, and science were considered.
3. The most recent Intelligence Quotient, Lorge-Thorndike or Kuhlman-Anderson, was obtained from the school records. The pupils with the highest IQ's whose grade point average was less than 2.00 were designated as the underachieving population.[1]
4. Seventy students with the highest IQ's in the underachieving population were designated as either control (30 pupils), experimental (30 pupils) or alternated (10 pupils) by random means.
5. Experimental classes were scheduled as a group with an experimental teacher. The control pupils remained in their original science classes provided they were not taught by an experimental teacher.

* Presented at the 18th Annual Convention of National Association for Research in Science Teaching, February 9, 1968, Chicago, Illinois.

[1] The population for the 7th and 8th grades was limited to those youth in science sections meeting the fifth and sixth periods. Randomization broke down at the 8th grade level for administrative reasons.

GUIDELINES FOR CREATING AN APPROPRIATE CLASSROOM ENVIRONMENT FOR EDUCATIONALLY DISADVANTAGED YOUTH APPLIED IN AND SUPPORTED BY THE PROJECT

1. Assumptions Made Regarding Educationally Disadvantaged Youth
   a. Human ability is to a large extent a social product. It depends upon the opportunities in the environment for meaningful and varied experiences. In many areas it does not develop unless recognized and encouraged by society.
   b. Educationally deprived children have had a narrow range of experiences in a limited environment, hence have a lack of confidence in themselves in a classroom situation.
   c. The conceptual development and the cultural heritage of educationally deprived children is inferior to that of children in more favorable environments.
   d. Because of limited experiences, educationally deprived children are limited in their ability to communicate with others orally or by means of reading and writing.
   e. The child who grows up in a culture of poverty has a strong feeling of fatalism, helplessness, dependence, and inferiority in social situations.
   f. By the time educationally deprived children enter school they have absorbed the basic attitudes and values of their subculture of poverty. As a result they are not ready to take advantage of the educational opportunities in the school or of opportunities that may come as a result of changed conditions during their lifetime.
   g. Any significant change in the relative position of the educationally deprived child requires a preferential treatment that will compensate for his inadequacies. These children require modified teaching techniques and a specially constructed curriculum if they are to succeed in school. They need special materials and devices to fill the gaps in their experience.
   h. Deprivation is largely due to failure of environmental agents:
      a. failure to provide children with necessary nourishment before they are ready to exercise specific capacities.
      b. failure to use and develop these capacities once they are ready for exercise.
   i. Although the preschool years are characterized by the most rapid change and growth and so are the most important years, yet the adolescent years are also a period of rapid change and growth, hence, these years are fruitful ones for the reorientation and development of educationally deprived children.
   j. Wherever poverty exists throughout the world there is a remarkable similarity in the style of life which may be called a "culture of poverty." This culture provides the human beings living in it with a design for living that permits their survival. This similarity is found in the structure of families, in interpersonal relations, in value systems, in spending habits, and in their tendency to live in the present with little thought of the future. The high incidence of common law marriages and of households headed by women are characteristic of this culture wherever it occurs.
2. Guidelines Used to Determine Science Experiences For Educationally Disadvantaged Youth
   a. Classroom studies should be related to the students' contemporary experiences in their society.
   b. A definite classroom situation must be provided in which new experiences with objects and events are related to past experiences in such a

manner that new relationships are discovered. By associating several new experiences during a short period of time, an awareness of the basic principles that account for these experiences may be developed.

c. Science experiences must be developed from the common interests of the learners and result in an understanding of the basic principles of science that are related to these interests.

d. Initial learning of first level abstractions comes from observations of particular objects and events via all of the senses. First hand experiences should be emphasized.

e. The major outcome of classroom experiences in science is to create in the educationally disadvantaged youth a desire to learn and a positive attitude toward school.

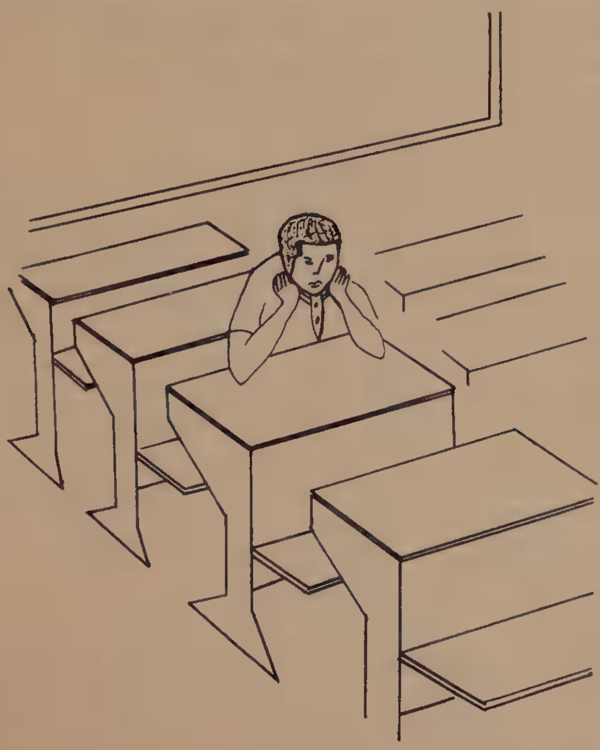
3. Guidelines Used to Determine How to Teach Science to Educationally Disadvantaged Youth
   a. Educationally deprived adolescents will have had many frustrating experiences so special care must be taken to enable each to succeed in each task undertaken. This success should be used to reinforce and to motivate further learning.
   b. The teacher must be willing for the child to deal primarily with specific objects, events, or persons as these objects, events or persons relate to himself, rather than to be concerned primarily with generalized activities.
   c. The teacher as a discussional leader accepts every response as a contribution and by questions, suggestions, and vocabulary directs the development of the concept.
   d. The teacher must be able to arrange a learning situation in which the youth's belief in himself, his self image, escalates. Each must operate responsibly in a self-directed way to build a confident self-image.
4. Guidelines Used to Select Science Experiences For Educationally Disadvantaged Youth
   a. Selection of topics for individual, small group or class investigation must provide avenues that insure success. Therefore, the investigations must center around directed inquiry rather than unassisted discovery.
   b. Each illustrative or investigative activity should:
      a. relate to the pupils' common experiences
      b. lead to a better understanding of the pupils' environment
      c. stem from and enhance the pupils' interests
      d. be specific rather than generalized, especially at the beginning
      e. furnish a basis for improving language skills, especially reading and oral expression
      f. be of measured difficulty so that each may succeed
   c. Each piece of apparatus should be:
      a. simple so that attention may be focused on significant observations
      b. so designed as to clearly show—perhaps to magnify—the quality being observed
      c. safe to use
      d. easy to manipulate
      e. relatively durable
      f. relatively inexpensive
      g. easy to store

TESTS USED

1. Otis Quick-Scoring Mental Ability Test: New Edition, Beta test, by Arthur S. Otis. The test is designed to be used in grades 4–9 and contains 80 statements and/or questions for which the best answer out of four or five is to be chosen.
2. Watson-Glaser Critical Thinking Appraisal by Goodwin Watson and Edward M. Glaser. Form YM was administered in the pre-test, and form ZM in the post test. The test is designed to be used in grades 9–16 and

contains 100 questions divided into five sub tests on: (1) Inference, (2) Recognition of assumptions, (3) Deduction, (4) Interpretation, and (5) Evaluation of arguments.

3. Student Attitude Scale by J. A. Battle.[2] This test was developed by J. A. Battle for the Kellogg Foundation Leadership Project (Pupil Human Relations Study), College of Education, University of Florida, 1953. The test contains 60 negative statements concerning the pupil's feelings toward himself, other pupils, teachers, administrators, and the school in general. The purpose of the test is to detect a change in attitude, not evaluate one's attitude.
   Students are to mark statements regarding how they feel as mostly true, half true-half false or mostly false by circling one of these: MT S MF. The test is so constructed that one's positive score is the number of MFs circled.
4. Projective Interviews (Picture Story Test). Only a random sample of experimental and control students from each grade level were interviewed. The test is designed to gain insight into the individual's perceptual organization and self-concept. In administering the test, the interviewer shows the subject four pictures, one at a time, and asks the subject to make up a story about the picture. The interview is recorded on tape. (See Page 8)
   The interviews are then transcribed for review by a panel of specially trained judges. Each transcription is identified by an anonymous number. Before the reviews take place, the pre-transcriptions and post-transcriptions are scrambled. The judges rated the transcriptions on a 0–9 scale on three bases:
   1. How does this person see himself? Does he lack confidence or is he self confident? Essentially negative, lacks self confidence or essentially positive, is self-confident?
   2. To what extent is this person identified with others? How does he see himself with others? Strongly alienated from others or strongly identified with others, particularly his peer group or gang?
   3. To what extent is this person open to new experiences? Closed, prejudiced, has distorted reactions, rejects his teachers and the school or essentially open and accepts new experiences, accepts his teachers and the school? The test was developed by James Parker who found that the projective technique was successful and consistent with presently accepted perceptual theory.[3]
5. A free writing projective exercise on "A Teenager's Advice to the School." This method of investigation into the adequacy of the individual was tested by Clifford Coursen who hypothesized that this would be a subtle, non-threat-



[2] Battle, J. A. "Techniques and Instruments for Measuring Certain Student Human Relations." Unpublished Doctoral Dissertation, College of Education, University of Florida, 1954.

[3] Parker, James. "The Relation of Self Report to Self-Report to Inferred Self Concept in Sixth Grade Children." Doctoral Dissertation, College of Education, University of Florida, 1964.

ening way of asking subjects how things appear to them and how they see the school.[4]

EVALUATION

The newly developed learning experiences were designed to harmonize with the stated objectives and assumptions. Close examination of these experiences showed that they do support the stated objectives and assumptions. From teacher reactions and other observations of student behavior, many clues of an improvement in attitude and interest in learning were evident in the treated classes. In fact these observations had much to do with the continuing interest and drive of those concerned with the project. However, such observations, vital in action research, cannot be analysed statistically.

In this pilot study which occupied but one-sixth of the school day for the duration of one semester, it would be quite remarkable to find any significant gains of the treated over the non-treated classes. Furthermore, the researchers were searching for evidences of change in attitude toward the school and the teacher, and in fact, did not even attempt to measure any changes in achievement in science. The original premise of this project was, that by participation in activities using "concrete" materials as a basis for developing facility in language, and working with these youth in ways that enhanced their self respect rather than destroyed it, that their attitude toward the school and toward their teachers would be improved. If their attitude was improved; they would become more open to the experiences available in the junior high school, and thus have a chance to take advantage of the education available to them, which up to this time, they have largely rejected. As a result they would be in a position to live their lives on a higher and more useful plane than would be possible otherwise.

From the classroom experiences in which the pupils use methods of scientific thought should come the knowledges, skills, and attitudes that enable them to cope more effectively with their everyday life experiences. With improved competencies, then the attitude toward the school and toward their teachers should improve. These youth should gain in self-confidence, tend to identify themselves less with the gangs who have a negative attitude toward the school, be more open to school experiences, and accept better what takes place in school.

To check on the composition of the treated and non-treated groups, the Otis Quick Scoring Mental Ability Test was administered.

When one compares the number of students with an intelligence quotient at or below the 90–94 range with those at or above the 90–94 range, one finds that they are distributed as shown in Table I.

The data in Table I demonstrates the similarity of the 7th and 9th grade groups where randomness was maintained, and the superiority of the 8th grade non-treated group over the treated group where randomness was ruled out. More than 70

[4] Coursen, Clifford. "The Relationship of Certain Perceptual Factors to Adequacy." Doctoral Dissertation, College of Education, University of Florida, 1963.

TABLE I

NUMBER OF STUDENTS WITH AN INTELLIGENCE QUOTIENT AT OR BELOW THE 90–94 RANGE COMPARED WITH THE NUMBER AT OR ABOVE THIS RANGE

	Treated Groups		Non-Treated Groups	
Grade	At or Below 90–94 Range	At or Above 90–94 Range	At or Below 90–94 Range	90–94 Range At or Above
7th	12	21	15	20
8th	25	9	16	23
9th	12	17	11	20

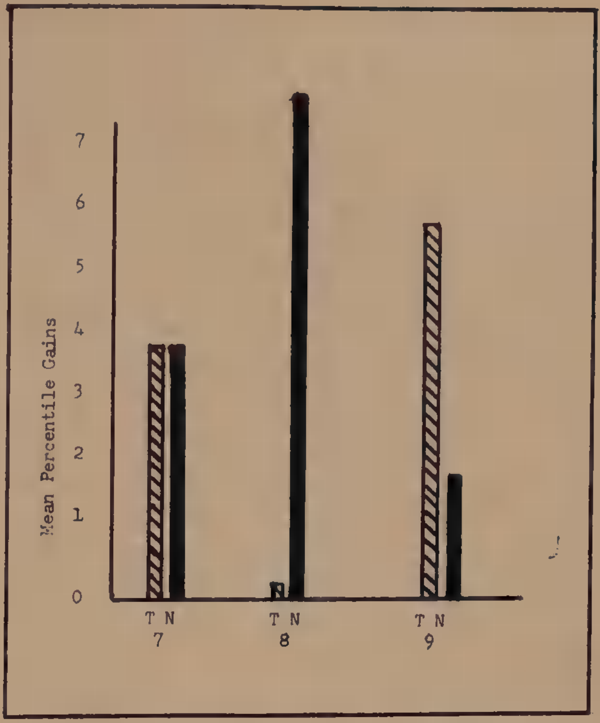
per cent of the treated 8th grade group were at or below the 90–94 range, while nearly 60 per cent of the non-treated group are at or above the 90–94 range.

To see if there were any significant changes in the ability to think critically accomplished during the experimental period, the Watson-Glaser Critical Thinking Appraisal was given as a pre-test and as a post-test.

Using the concept of covariance analysis as presented by Lord,[5] t tests were run for significance between treated and non-treated groups by grade level with the results being shown in Table II. As may be seen in the entrance of the Watson-Glaser Critical Thinking Appraisal Data, there is no significant difference in the gains made by the treated and non-treated groups at any of the grade levels tested.

Even though the data presented in Table II showed that there were no significant differences in the percentile gains on the Watson-Glaser Critical Thinking Appraisal test, it seemed advisable to graph the results obtained and to look for any trends that may be noted. The gains of the non-treated group over the treated group at the eighth grade level appear considerable. Perhaps these gains displayed in Graph #1 may be accounted for by the superior intelligence of the non-treated 8th grade group over the treated 8th grade group.

[5] Lord, Frederick M., "Large-Sample Covariance Analysis When the Control Variable is Fallible," *American Statistical Association Journal,* 55:307–334, June, 1960.



GRAPH 1. Gains in percentiles of the means of the treated and non-treated groups on the Watson-Glaser Critical Thinking Appraisal.

With similar populations at the 7th and 9th grade levels, one might ask if the trend noted in the 9th grade might not be attributed to the special treatment given the experimental group.

To look for changes in attitude the Student Attitude Scale by Battle was administered as a pre and post test. The average gain was then calculated. The results are shown in table #3 and graph #2.

According to covariance analysis as presented by Lord,[6] t tests were run for significance between the treated and non-treated

[6] Lord, *Ibid.*

TABLE II

PERCENTILE GAINS IN THE ABILITY TO THINK CRITICALLY OF TREATED AND NON-TREATED GROUPS ACCORDING TO WATSON-GLASER CRITICAL THINKING APPRAISAL

	Treated					Non-Treated					
		X					X				
Grade	N	Pre	Post	Gains	s	N	Pre	Post	Gains	s	t
7	27	10	14	4	2.3	32	12	16	4	1.1	.440
8	29	14	14	0	2.4	24	14	22	8	1.8	.888
9	21	16	22	6	1.3	29	24	26	2	1.1	.568

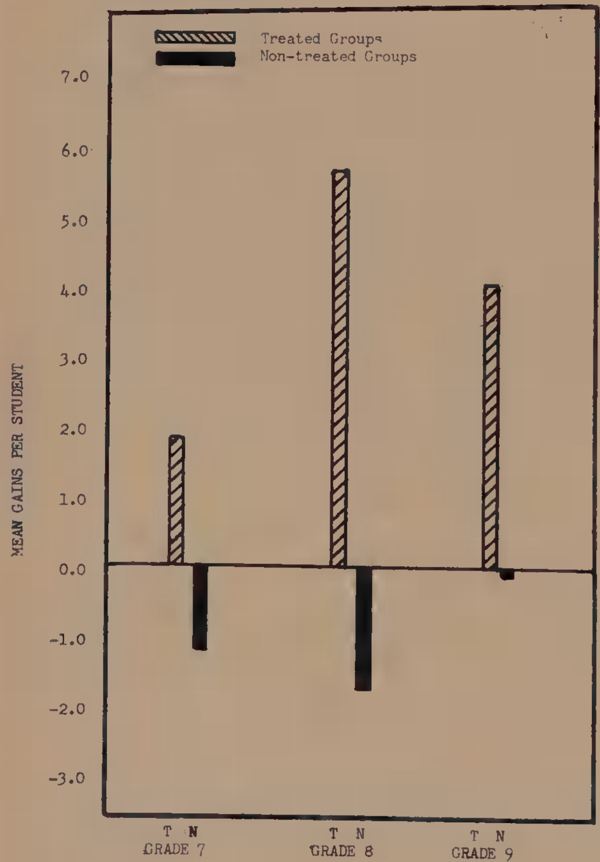
TABLE III

STUDENT ATTITUDES OF TREATED AND NON-TREATED GROUPS ACCORDING TO BATTLE STUDENT ATTITUDE SCALE

Grade Level	Treated				Non-Treated				t
	N	X Pre	X Post	s	N	X Pre	X Post	s	
7	28	24.4	26.1	8.426	30	24.5	23.4	7.416	.53 Not Sig. @ .05
8	23	17.4	23.2	7.483	32	22.5	20.8	3.317	3.6266 Sig. @ .01
9	21	26.3	30.3	6.782	29	28.5	28.2	No Correlation	

groups on the Battle Attitude Scale. The results of the t test are shown in Table III. The scores of the eighth grade treated group are significantly higher than those of the non-treated group at the .01 level.

When the results of the Battle Student Attitude Scale are represented graphically



GRAPH 2. Mean gains for students of the treated and non-treated groups on the Battle Student Attitude Scale.

as in Graph #2 on the following page, it is found that the trend in all cases is in favor of the treated over the non-treated groups. The scores of each treated group improved while the scores on the post test of each of the non-treated groups dropped.

The significance of the trend becomes more realistic as one analyzes the statements found in the Student Attitude Scale, using the same rating scheme applied in judging the projective interviews, namely, self confidence, identification with others, and acceptance of the school and school personnel. Nine of the 60 questions relate to how one sees himself, twelve relate to the extent to which one identifies with others, and thirty-nine questions, approximately two-thirds, relate to the extent one accepts the school and the school personnel.

In the light of Graph #2 and the previous statements about the scale, is it not possible to draw the following conclusions?

1. The students in the classes developed a more wholesome attitude toward their teachers and toward the school while those in the non-treated classes developed a more negative attitude or remained unchanged. Isn't it reasonable to attribute this improved attitude to the special treatment provided in the experimental classes?
2. The eighth grade treated class evidenced the greatest change, significant

at the .01 level. It will be recalled that the intelligence scores of this treated group were less than those of the non-treated group, that the randomization of this group was destroyed due to administrative difficulties. Is it not possible that these results are even more significant regarding the approaches and the special curriculum, for this demonstration-research project was directed to the economically deprived low achievers who are also under-achievers?

3. Does not the positive change in attitude of the experimental groups support the assumption made earlier that any significant change in the relative position of the educationally deprived child requires preferential treatment?

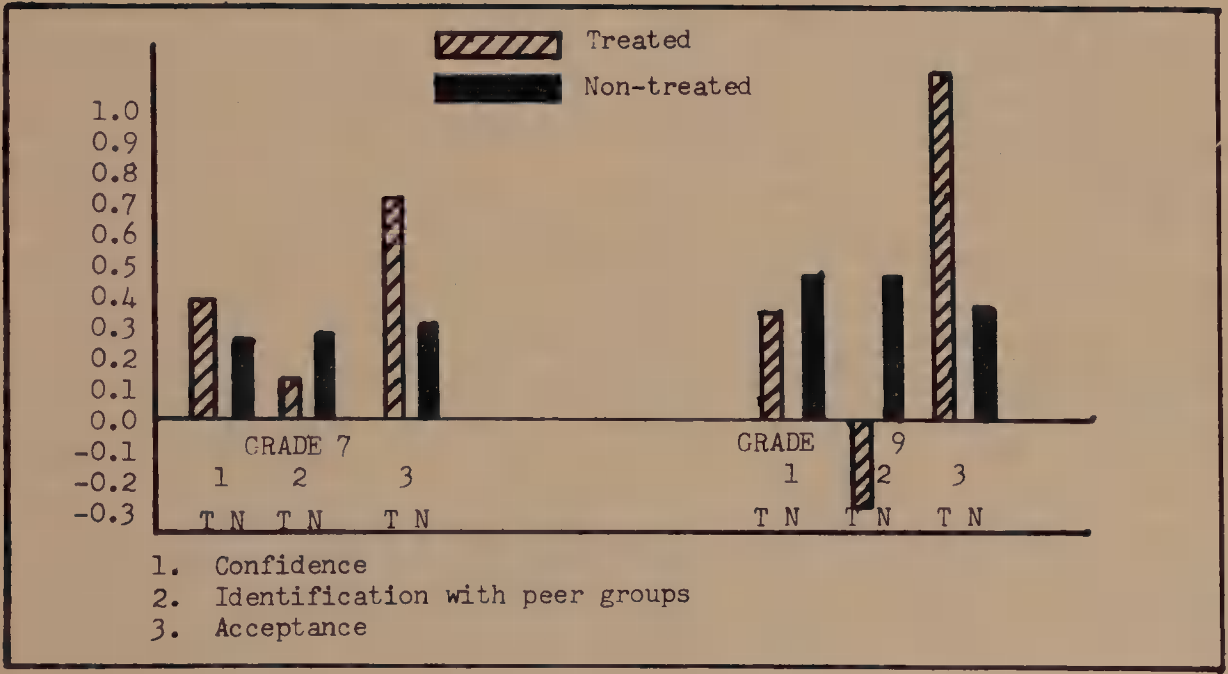
The results from the projective interviews are in harmony with those on the student attitude scale.

These interviews were given by a research assistant specially trained in educational psychology. Transcriptions of the interview were made, and then those given before and after the completion of the project were mixed before being judged.

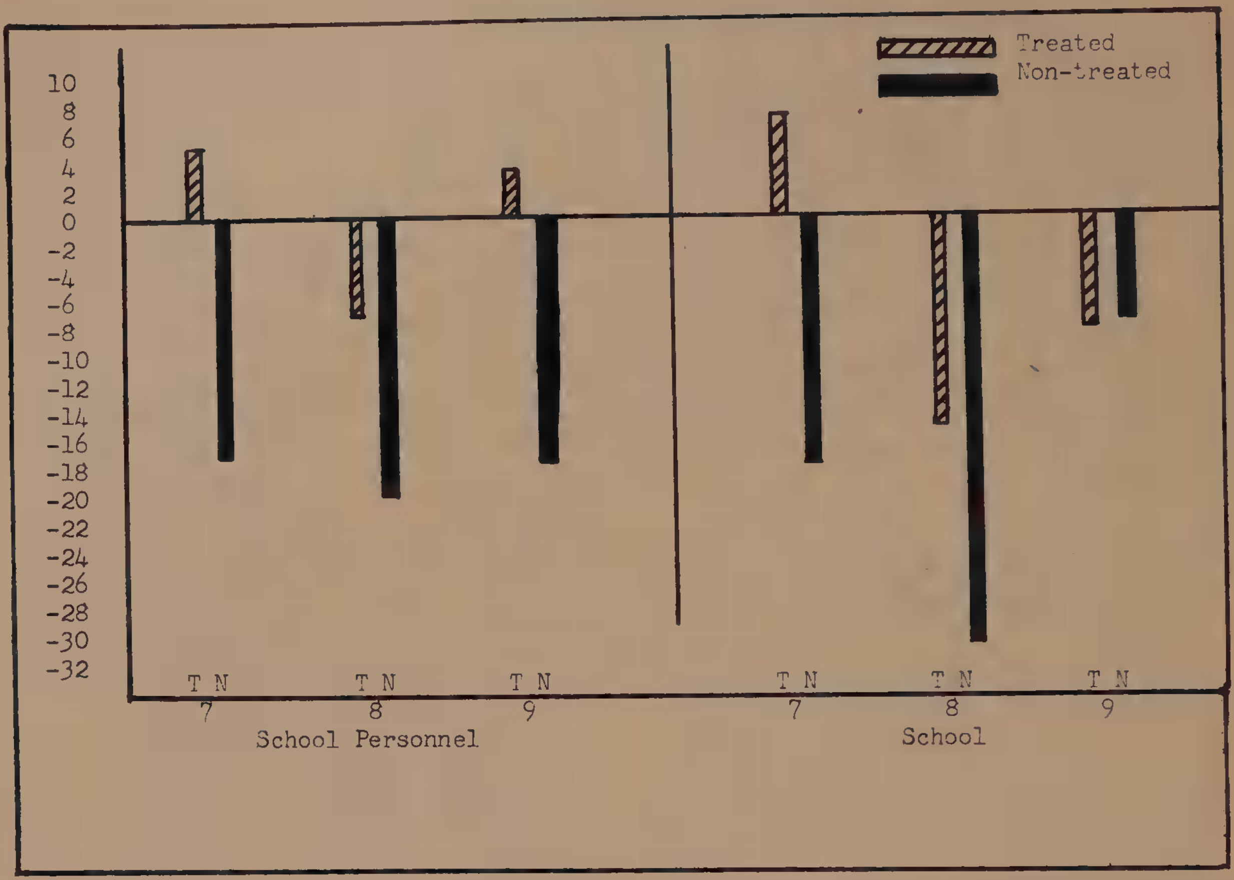
Numbers 1 in the Graph #3 represent the average gains of the students in self confidence; numbers 2 represent the average gains in identification with others, particularly with peer groups or gangs; and numbers 3 represent average gains in accepting new experiences in the school and in accepting school personnel. Negative shift in numbers 2 was considered as evidence of a positive attitude toward the teachers and the school. These disadvantaged youth must in many cases become alienated from their peer or gang groups if they are to be open to what the school has to offer. So, the researchers interpreted a positive shift in numbers 1 and 3 and a negative shift in numbers 2 as desirable. Such a shift would be in harmony with the results obtained from the Battle Student Attitude Scale.

There is little shift in the gains made by any of the groups on numbers 1. What happened in this brief experience was not sufficient in competition with all the other influences that impinge on the students to make any noticeable change.

Both at the seventh grade level and at the ninth grade level, there is evidence that the students in the treated group, in reference to the non-treated group, became less identi-



Graph 3. Distribution of the mean gains of the treated and non-treated groups on the Projective Interviews.[6]



GRAPH 4. Gains made in the number of students making positive statements over the number making negative statements toward school personnel and toward the school in each of the treated and non-treated groups on the written projective test.

fied with their peer group, that is, they became more alienated from their gangs; and they became more open to what the school had to offer, their acceptance of the school and the professional staff improved. Perhaps if this demonstration research could be extended over a three year junior high period some evidence might accumulate.

Projective essays were written by both the treated and non-treated groups before and after the teaching experiences. Following the conclusion of the experimental period, a group of four judges examined the written statements of the students on the topic, "A Teenager's Advice to the School . . ." At first it seemed impossible

TABLE IV

MEAN GAINS OF THE TREATED AND NON-TREATED GROUPS ON THE PROJECTIVE INTERVIEW *

Treated Groups									
Grade Level	Self Confidence			Identification			Acceptance		
	Pre	Post	X	Pre	Post	X	Pre	Post	X
7	2.6	2.9	0.3	3.2	3.2	0.0	2.5	3.1	0.6
9	4.2	4.5	0.3	4.4	4.3	—0.1	3.9	4.9	1.0
Non-Treated Groups									
Grade	Pre	Post	X	Pre	Post	X	Pre	Post	X
7	2.9	3.1	0.2	3.4	3.6	0.2	3.2	3.4	0.2
9	3.0	3.4	0.4	3.1	3.5	0.4	3.0	3.3	0.3

* Unfortunately most of the eighth grade pre test tapes were erased so results for the 8th grade are not shown.

to judge the statements. Then it was decided to treat the results as follows: One person read the papers while the judges as a group responded to statements on two bases, namely, (1) Do the statements show a negative or a positive attitude toward the teachers and other school personnel? and (2) Do the statements show a negative or a positive attitude toward the school? Tallies were made of the negative and positive attitudes agreed upon by the judges. In many cases there was no tally, for the statements did not reflect any such attitudes. A comparison of the gains made in the number of students making positive statements over those making negative statements in the post tests over the number in the pre tests is shown in Graph #4.

SUMMARY

It is interesting to speculate on the results displayed in this evaluation section. Are the results found in this pilot study representative of all low achievers? Would those low achievers who are also underachievers be as negative or more negative than those who simply can't learn? If the eighth grade treated group had the ability of the eighth grade non-treated group might they have remained positive in their attitude toward their teachers as did the seventh and ninth treated groups?

Could one draw the following conclusions for the group tested in this project?

1. Preferential treatment must be provided if educationally disadvantaged underachieving youth are to be kept from developing a negative attitude toward the school personnel and toward the school.
2. Treatment such as was provided in this project almost enables these educationally disadvantaged underachieving youth to maintain a positive attitude toward their teachers. With an extension of such treatment throughout the school day, a positive attitude toward the school might also be maintained.
3. The results obtained in this written projective essay are in harmony with the results obtained on the Battle Student Attitude Scale and on the Projective Interviews. In all of these the special treatment provided which dealt with these students as people of worth, and which provided "concrete" experiences out of which language can develop, enabled many of them to maintain a wholesome attitude toward their teachers and toward the school.
4. Is it not likely, that if preferential treatment with a specially constructed science program is provided throughout the junior high school program, that a majority of the economically deprived underachievers will be successful in their studies?

POSTSCRIPT

At present the individuals who conducted this pilot demonstration project are engaged in a greatly extended one largely supported by the Duval County Public School System, in which they are involving educationally disadvantaged underachieving youth in a carefully designed special program in science at the 7th, 8th, and 9th grade levels. This project is entitled "DISCUS"—A Demonstration of An Improved Science Curriculum for Underachieving Students.

The extended project is being implemented in fourteen schools. These include all of the schools having the highest percentage of educationally deprived underachieving youth.

There are thirty-two experimental classes being taught by 27 teachers and a similar number of control classes and teachers.

The 27 teachers were randomly selected from a pool of 54 teachers willing to participate in the program.

The 1000 youth in the experimental groups and alternates with a similar number in the control groups were randomly selected from a pool of 2400 educationally deprived underachieving youth.

Project DISCUS is proving a very challenging experience for all of us who are involved in it.

THE SCIENCE MANPOWER PROJECT: ITS HISTORY AND ITS PROGRAM

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As early as 1953 officials of Teachers College, Columbia University pointed out that the elementary and secondary school science programs of various school systems were sadly deficient, and that insufficient numbers of scientists and engineers were being educated to meet the needs of the national economy. At this time enrollments in the high-school sciences, and particularly in the physical sciences, had reached a low ebb.

Planning for a Science Manpower Project was begun in 1954. The Science Manpower Project was dedicated to the improvement of science education in the nation's schools, and the cultivation of student interest in science and science-related careers. *Associates* in representative teacher-training institutions across the land were selected, and rotating groups of *Fellows* were recruited to work at Teachers College, Columbia University. Support for the Project was obtained from leading American industries and foundations, and operations began in September, 1956.[1]

In the year 1956 there was no special public concern about programs of science education. Yet the preceding year all American colleges and universities combined had produced only 1996 graduates[2] who had majors in physics. Other comparable figures for academic year 1954–1955 were 5920 graduates with majors in chemistry, 1414 with majors in bacteriology, 11 with majors in astronomy, and 5493 with majors in biology. Overlooking questions concerned with quality, the education of new personnel at such a level obviously was not adequate to meet the requirements of industry, government, defense, and instruction. But 1956 was a year of relative complacency. The word *sputnik* had not yet been heard in the land, and the scientific enterprise of the United States was commonly regarded as being beyond the reach of any foreign challenge. Public awakening to a more realistic appraisal was disconcertingly abrupt, and in due course of time attention was focused upon the lagging program of science education in American schools.

In the post-sputnik period, which began in the autumn of 1957, it was not at all difficult to obtain a hearing for the needs of science education. In fact, many individuals, both within and without educational circles, began to voice alarms and to suggest a variety of remedies; some of the latter were not especially enlightened or practicable, but they were well intended, and they had the effect of directing public attention to a national problem of real sig-

[1] Industries and foundations that made contributions to the support of the Science Manpower Project in 1954 and later included the Aluminum Company of America, American Electric Power Company, the American Metal Company Foundation, the Armco Foundation, the Arthur D. Little Foundation, the Auto-Lite Foundation, Bell Telephone Laboratories, the Bridgeport Brass Company, the Bullard Company, the Climax Molybdenum Company, the Continental Can Company, the Crown Zellerbach Foundation, the Esso Educational Foundation, the Ethyl Corporation, the General Dynamics Corporation, the Gillette Company, Handy and Harman, the International Business Machines Corporation, the International Nickel Company, the International Telephone and Telegraph Corporation, Johnson and Johnson, the Kennecott Copper Corporation, the Link Foundation, the Ohio Oil Company Foundation, the Pfizer Foundation, the Pittsburgh Plate Glass Foundation, the Proctor and Gamble Fund, the Reynolds Metal Company, the Robert Gair Company, the Rohm and Haas Company, the Sperry Rand Corporation Foundation, the Standard Oil Company of California, Sylvania Electric Products, the Union Carbide Educational Fund, the W.W. Welch Manufacturing Company, the West Virginia Pulp and Paper Company, and the Westinghouse Educational Foundation.

[2] Bachelor of Arts and Bachelor of Science degrees.

nificance. The first order of business now became one of providing guidance for teachers and administrators at the local level; these people were under pressure to activate or reconstruct science programs, and they were assailed by a multitude of voices conveying advices that often were contradictory. The Science Manpower Project was fortunate in that it had been established at a time when there was growing disposition on the part of the public, the scientific community and school personnel to support changes, and also a time when schools were most willing to receive assistance in directing such changes.

GOALS

The project was scheduled for an active existence of five years. This period was to be devoted to fact finding, the writing of policy report and recommendations, and the preparation of various curriculum materials for use in planning science education programs. The initial goals were

(1) to clarify the nature of the problems involved in improving science education,
(2) to exert an influence upon the public and the schools and to arouse interest in the improvement of science programs,
(3) to provide guides for the improvement of instructional programs, and
(4) to foster changes in teacher education designed to produce a larger and more effective corps of science teachers.

Due to public concern about Soviet advances in science and technology, the need to implement the second of these goals was soon minimized. Meanwhile, continuous pressure from schools that were hastening to revise and modernize their science offerings served to concentrate effort upon the third goal, somewhat at the expense of new designs for teacher education. But as modified by events of the times, the activities of the project operated on schedule, and when the five year period ended, the materials planned for production had been made available to the schools.

PROJECT PERSONNEL

Several groups of individuals participated to greater or lesser extent in the activities of the project. These groups were as follows:

1. *Directors of the Project.* General direction of project activities was vested in F. L. Fitzpatrick, Director, and W. J. Jacobson and the late H. M. Evans, Associate Directors.

2. *The Joint Industry-Education Advisory Council.* This group was largely composed of representatives from participating foundations and industries, but included some members drawn from the ranks of the academic sciences and education. The Council's function was to meet semi-annually with the directors of the Project, to review progress, and to redirect effort to be consistent with the march of events.

3. *The Corresponding Advisory Council.* The relationship of this group to the Project was similar to that of the Joint Industry-Education Council, except that the exchange of ideas was carried out by correspondence. The group was established in recognition of the fact that certain participating industries located at considerable distance from the seat of operations might find it difficult to be represented at the semi-annual meetings of the Joint Industry-Education Advisory Council.

4. *Associates of the Project.* Over 60 science educators and scientists located at an equal number of colleges and universities served as Associates of the project. To them a sincere vote of thanks is due, inasmuch as they were called upon from time to time to review proposals and written materials, and to contribute ideas relating to various phases of the effort. Many of them also participated in the distribution of project materials to teachers and the schools. The names of these Associates

are not listed here because they have been recorded in an earlier article.[3]

5. *Fellows of the Project.* During each year of the Project's active existence, a group of Fellows was in residence at Teachers College, Columbia University. These Fellows included science teachers from the schools, academic scientists, and staff members of teacher-training institutions. The Fellows carried out much of the work of the Project, and the fellowship program was viewed as a laboratory for the preparation of leaders in science education. The cumulative roster of this group, with present locations insofar as they are known, follows:

Allen, Dr. Hugh, Jr.	Montclair State College (N.J.)
Behnke, Dr. Frances L.	Teachers College, Columbia University
Carr, Dr. Albert B.	University of Hawaii
Cox, Dr. Louis J.	Towson State College
Cullmann, Dr. Ralph E.	Newark State College
Davis, Dr. Jerry B.	Hofstra University
D'Ambrosio, N.	Paterson State College (N.J.)
Dean, Dr. Peter M.	International Business Machines
Eller, Dr. Frank W.	East Carolina State College
Erickson, Dr. J.W.	Teachers College, Columbia University
Feifer, Dr. Nathan	San Francisco State College
Feldman, Dr. Dorothy G.	Bronx Veterans Hospital
Felton, Dr. N.M.L.	San Jose State College
Fischler, Dr. A.S.	Nova University
Ford, Renee	International Science and Technology Institute
Gard, Dr. Walter F.	Orange County Community College (N.Y.)
Hugny, Rollin P.	Advanced Studies Program St. Paul's School
King, Dr. Robert N.	Glens Falls Public Schools (N.Y.)
Kingery, B.T.	Newark School of Engineering
Lee, Donald E.	Riverside, California
Mills, Dr. Lester	Ohio University
Olinsky, Sylvia	Southern Connecticut State College
Petrik, Dr. Eugene	Seton Hall University
Pierce, Dr. E.F.	State College at Geneseo
Pitts, James T.	Port Jefferson Public Schools (N.Y.)
Pugno, Dr. Lawrence	San Jose State College
Rio, Dr. Francis J.	Northern Connecticut State College
Sattler, Dr. Louis	Brooklyn College
Stewart, Dr. H.H.	Florida Atlantic University
Stone, Dr. Dorothy	New York Medical College
Strawcutter, R.M.	Indiana State College (Penna.)
Tannenbaum, Dr. H.E.	Hunter College of the City University of New York
Trieger, Dr. Seymour	Board of Education of the City of Toronto

The Fellows constituted the working and writing group. They met in weekly seminars with the officers of the project, and often with visiting scientists or representatives of industry. Meanwhile, they were primarily responsible for the preparations of written materials designed to expedite the efforts of science teachers.

THE PROJECT IN ACTION

As an example of one phase of project activities, we may cite the case of the development of the monograph in the junior high school science program. The desirability of preparing a monograph on this subject was first reviewed by the Joint Industry-Education Council. One of the Fellows, Dr. A. S. Fischler, was then designated to take the lead in the preparation of recommendations and supporting materials. He thereupon drew up tentative proposals, which were submitted to an appropriate group of the Associates for criticisms and suggestions. Returns from

[3] Fitzpatrick, F.L. "The Science Manpower Project," *Science Education*, 43: 121–125, March, 1959.

the Associates were evaluated; the most acceptable pattern of recommendations was determined, and these recommendations became the basis for production of the monograph. In retrospect this sounds fairly simple and straightforward, but actually, this was far from being the case. For one thing, predetermined policy envisaged the development of an *articulated program* of recommendations, to provide for a continuous sequence of studies beginning in the kindergarten and extending through the grades of the elementary school, junior high school, and senior high school. It was therefore necessary for Dr. Fischler to work in concert with the individuals who were preparing monographs for (a) the elementary school sequence, and (b) the science offerings in the senior high school.

In the production of such policy recommendations, the approach was that of providing the teachers and curriculum committees at local and state levels with a guide which might be used in modernizing, strengthening, and articulating their own science programs. This approach was quite different from that of submitting a detailed course of study to the schools on a "take it or leave it" basis. In this approach it is recognized that communities, material circumstances, teachers, and student groups vary, that there must be some recognition of this variation in the science education program of any school system, and that professional people at the local and state levels are best able to make these adaptations.

When a monograph such as that just described had been published, it was distributed to the Associates in other teacher-education centers, and to a large number of school systems that had been placed on the mailing list of the project. It was also made available for sale to individuals and the schools.[4] Various meetings of national societies provided further opportunity to "spread the word." Presentations of policy recommendations and of program materials were made before members of the National Science Teachers Association, the Central Association of Science and Mathematics Teachers, the Association for the Education of Teachers in Science, the Michigan State Science Teachers Association, and at a number of regional meetings of school superintendents and principals sponsored by the American Association for the Advancement of Science and the United States Office of Education in the autumn of 1962. Through the efforts of Dr. Howard Meyerhoff, Executive Director of the Scientific Manpower Commission, the activities of the Science Manpower Project were reported regularly in *Science Education News*.[5]

THE POLICY REPORT

During the early days of the project, letters received from various officials of school systems made it apparent that a general plan for the reorganization and administration of science programs was in marked demand. Such requests for assistance proved somewhat embarrassing, because it was virtually impossible to respond to them by way of ordinary correspondence. To deal with this problem more adequately, the Director, the Associate Directors, and a group of the Project Associates undertook to prepare a monograph setting forth general policy recommendations.[6] The Associates who participated in this effort included Alfred D. Beck, Science Supervisor, Junior High Schools, New York City; Francis J. Bernard, Director of the Science Teacher Training Program, Iona College; N. Eldred Bingham, Professor of Science Education, University of Florida at Gainesville; Paul Blackwood,

[4] To obtain price lists and place orders, communications should be directed to the Teachers College Press, Teachers College, Columbia University, New York, New York 10027.

[5] A publication of the American Association for the Advancement of Science.

[6] Fitzpatrick, F. L. (ed.) *Policies for Science Education.* Teachers College Press, Teachers College, Columbia University, New York, N.Y. 10027.

Specialist for Elementary Science, United States Office of Education; John G. Navarra, Head of the Science Department, Jersey City State College; Robert Stollberg, Professor of Physical Science, San Francisco State College; Harold Tannenbaum, Chairman, Department of Curriculum and Teaching, Hunter College of the City University of New York; John Urban, Head of the Science Department, State University of New York College of Education at Buffalo; Fletcher G. Watson, Professor of Education, Harvard University, and Leonard Winier, Professor of Biology, Iowa State College.

The policy report reviewed science manpower needs, and proposed a sequence of science courses for the elementary school, junior high school, and senior high school. In it general administrative problems that relate to the science program, including personnel, equipment, and problems of the preservice and inservice education of teachers were discussed. The Policy Report was designed for use by the school administrator and others who have overall responsibilities for establishing policies and procedures related to science education.

THE K-12 SCIENCE PROGRAM

In the past few decades the importance of science and technology in our individual lives and in our society has increased markedly. We may hope that the educated man of the future will have some understanding of the important generalizations of science, just as we have always expected him to have some acquaintance with the literature, music, and art of his culture. In addition, we all use the fruits of science and technology in our daily lives. In fact, a growing proportion of our population functions in scientific occupations and professions.

The importance of the scientific enterprise in modern life places new demands upon our schools. On the one hand, the schools have a key role in educating the scientists and technologists of the future—a future in which a continuing population increase seems highly probable, and expansion of the national economy is anticipated. In this context, the schools must prepare citizens who have enough understanding of science and technology to make sensible decisions about a multitude of problems in which science and technology provide keys to solutions.

To prepare scientifically literate citizens and, at the same time, meet scientific manpower needs requires planning. Too often in the past the science experiences of elementary schools, junior high schools, and senior high schools have been planned without reference to "what the other fellow is doing." Unfortunately, this leads to tiresome repetition of relatively simple concepts at successive levels of instruction and generally ineffective programs. This can be avoided if science sequences are planned on a K-12 basis.

In fact, the development of K-12 science programs is one of the most challenging tasks of the science educator. Such programs are not conceived of as being uniform throughout the land, although they must necessarily have various common elements. In some way or another, they must deal with the important aspects of science including the new as well as the traditional. They must be devoid of interest-deadening repetition, but at the same time help young people build upon their previous science experiences. The K-12 sequence designed by the Science Manpower Project represented a sort of template, which could serve as a basis for the development of appropriate programs at the local level.

At this point it is appropriate to note that teachers and curriculum planners must have some concept of the directions in which they hope that pupils and students will develop. Moreover, statements of goals should have operational meanings; i.e., they should have meanings in terms of our day-to-day work in teaching science. The following were among the goals of the

Science Manpower Project's K-12 science program, with concrete examples that gave them operational significance:

1. *To develop a better understanding of the physical world.* This has always been one of the most important objectives of science teaching. We want our youngsters to possess an adequate *weltanschauung*: a reasonably complete picture of the world in which they live, and a rational idea of their place in this world. This goal becomes critically important in this age when our knowledge of the world appears to be increasing geometrically. We live in a vast universe; recognition of this vastness has challenged our imaginations and opened new vistas for exploration. The development of a view of our world which is consistent with the evidences emerging in a wide range of sciences is essential for optimum growth and development.

Almost all of our science activities should contribute to the achievement of this goal. One example from the Science Manpower Project's program is the study of two hypotheses concerning the origin of the universe: the *evolutionary* or "big bang" hypothesis, and the *steady state* or continuous-creation hypothesis. What are the observations that support any such theory? How do these two hypotheses relate to the observations? What are some possible ways that we might test these hypotheses? This is one example, among many, of an area of study that will help young people develop a more adequate picture of the universe.

2. *To help young people gain some understanding of the methods and processes used in the sciences.* This category is really a continuation and elaboration of some of the elements in No. 1. Methods used in the sciences are among the most powerful intellectual tools man has developed, and some of these methods can be used to deal with questions and problems that students recognize. In the scientific approach, suggested answers or proposals for action are subjected to empirical, experimental tests. For example, a few years ago statements could be found in print to the effect that the deer fly can travel at speeds in excess of 700 miles per hour, although this figure approaches the speed of sound in air. But, when subjected to an empirical test, the flight speed of the deer fly was found to be much less than 700 miles per hour. This case emphasizes the fact that in science an attempt is made to have the findings of one person checked by others. Thus, when it was reported that Hahn and Strassman had fissioned U-235 to produce elements near the middle of the periodic table, American scientists did not wait for the meeting to close before they set out for their laboratories to verify this discovery.

As young people engage in various kinds of science activities, it is extremely important that they be made cognizant of the methods employed. In a recent laboratory experience, some students were sprouting seeds by placing them on wet blotting paper between two pieces of glass. They were trying to find out whether it made any difference which end of the seed was up and which was down. However, one of the students was not satisfied. He asked, "What would happen if a full grown plant were turned upside-down?" The teacher countered with the question, "How could we find out?" The immediate response was, "Try it." However, the teacher hesitated and asked, "After trying it, how would you know whether turning the plant upside down had made a difference?" The students then suggested a control; growing another plant rightside-up. Also, before "trying it," the teacher asked them to suggest hypotheses as to what might happen. After carrying out the experiment, the students were directed to check in textbooks, trade books, pamphlets, and journals to see if they could find other accounts of this experiment, and whether their results were consistent with those obtained by others. What might have been only a prosaic science activity became a rather

interesting demonstration of some of the methods used in the sciences.

3. *To learn more about their bodies and how to take care of them.* Knowledge about the human body has been developed in such subsciences as physiology, pathology, immunology, chemotherapy, and nutrition. Average life expectancy has been increased about 20 years in the last half century. However, health is more than the mere absence of disease. It is a state in which each individual can operate at his optimum effectiveness. Few individuals attain this highly desirable state. Through the study of the human body and how to care for it, students can come closer to achieving this goal. The study of the human body and how it works is especially important for the early adolescent, for he is at a stage when profound, and to him mystifying, changes are taking place in his body.

Many students have studied the effects of various kinds of diets upon growth and development. These studies are usually made with white rats. The laboratory rat has various nutritional requirements that are similar to those of humans, and effects of nutritional deprivation appear relatively soon in the case of the rats. Studies usually take the form of controlled experiments, in which some rats are given an adequate diet, while other rats subsist on a diet deficient in some nutrient. Students learn how to set up a controlled experiment, make observations, secure and record data, interpret data, and perhaps discover that "what you eat makes a difference."

4. *To learn what it is like to work and study in science.* Guidance has always been an important dimension of the junior high school program. Much basic work should be done in such areas as science, industrial arts, social studies, mathematics, and English. As a part of this study students should begin to acquire an understanding of what it is like to work in occupations and professions related to science. They should also learn something about the kinds of preparation they will need for various occupations and professions. In the senior high school they will begin to make choices among subjects in the school program. Since basic courses in science and mathematics are often prerequisites to more advanced study, it is essential that students keep the doors to future opportunities open.

Guidance is an important feature of the Science Manpower Project's program of junior high school science.[7] In each unit of the sequence some attention is devoted to the nature of the work in scientific occupations related to the subject matter of the unit. Field trips to factories, laboratories, farms, and government agencies are encouraged, and scientists and engineers are often invited to contribute as a class studies various phases of the subject matter. In the final unit of the three year program there is serious consideration of science in the future, and the opportunities that young people will have in the scientific enterprise.

5. *To prepare for effective citizenship.* In our democracy, citizens and their elected representatives have to make decisions concerning conservation of natural resources, agricultural policies, transportation, communication, atomic energy, public health, national defense, space explorations, industrial developments, air and water pollution, and education. Science and technology are involved in nearly all of the decisions, and if the decisions are to be intelligent, our citizens have to know something about the basic science and technology that is related to the various problems. For many future citizens, the K-12 science program provides the last opportunity for an organized study of the wide range of sciences. The responsibility for the future effectiveness of our democratic way of life that must be shouldered by teachers of science is indeed impressive.

Perhaps one of the best ways to prepare

[7] Fischler, A. S. *Modern Junior High School Science.* Teachers College Press, Teachers College, Columbia University, New York, 1961.

for effective citizenship is to have experience in studying, analyzing, and suggesting possible solutions for current community, regional, state, national, and international problems related to science and technology. In the Science Manpower Project's proposal, for example, problems of the conservation of biological resources are considered at the community level, problems related to energy sources at the regional level, and problems concerned with atomic energy at national and international levels. In considering these problems, methods of study and analysis are emphasized, for as time goes on, the nature of the problems will change, but it will always be helpful to seek pertinent information, to know how to use the findings of experts, and to give consideration to honest differences of opinion.

PROGRAM

A number of approaches might be followed in efforts to develop more effective school science programs, and this is significant in view of the fact that communities, student groups and teaching staffs vary in a multitude of ways. For reasons such as the foregoing, the program of studies sponsored by the Science Manpower Project has its greatest potential utility as a *guide to the establishment of science sequences at the local and state level.* But it is believed to have a number of important characteristics that should be represented in any program modeled upon it. These characteristics are as follows:

1. *A wide range of science content is included.* In recent decades our scientific knowledge has been expanded at a rapid rate. Much of the new knowledge is highly significant, and must be at least considered for inclusion in revised courses of study. It has become inconceivable to ignore the potential contribution of astronomy, astronautics, biochemistry, biophysics, immunology, oceanography, and meteorology.

2. *The recommended program is articulated.* So much challenging material is available for inclusion in science programs that repetition of various learning experiences at essentially the same level of difficulty is a practice to be avoided. Yet it is a practice that has characterized many curriculums up to the present time. In the Science Manpower Project's proposal a broad spiral approach has been employed, so that a given area of knowledge is dealt with every third or fourth year, and in all cases an attempt is made to use a fresh approach at a more sophisticated level.

3. *Provision is made for study in depth.* Making more time available for science instruction at the lower levels of the school and eliminating repetition makes it possible to consider blocks of subject matter in greater depth than has previously been the case. There also is more time to consider scientific methods of study and analysis, and to employ the problem-solving approach.

4. *Important generalizations are emphasized.* The significant concepts, principles, and theories of science serve as guidelines in curriculum planning, and gaining an increasing understanding of them is one of the goals of instruction. At the same time, the interrelationships of the various sciences are considered, as well as the interrelationships of the scientific enterprise with non-science areas of knowledge.

5. *A variety of teaching methods is encouraged.* In teaching the K-12 program of the Science Manpower Project it is assumed that a variety of approaches to teaching will be employed. It is a case of using the methods and materials best suited to a particular objective, and taking into account the teacher's resources and the particular student group under instruction.

SCIENCE FOR THE ELEMENTARY SCHOOL

The Science Manpower Project's program for the elementary school has two dimensions: a *flexible dimension* and a *planned dimension.* In the former, pupils have many experiences that originate with their own questions, or with projects they

undertake, or with community events. In the latter, however, there is an organized attempt to introduce the pupils to six broad areas of science. It is believed that the classroom teacher-science consultant team can provide this instruction most effectively, but it is a program that can be and is being taught by classroom teachers alone.

In setting forth their recommendations for the elementary science sequence [8] Jacobson and Tannenbaum [9] noted that certain criteria should be kept in mind in developing such a program. These criteria, in substance, are as follows:

1. The program should be consistent with our tested knowledge of child development.

2. The experiences should nurture pupils' natural curiosity or desire to "find out." Questions and problems that children raise should be analyzed and studied.

3. There should be many opportunities for direct experiences with materials of the environment. Children should learn to handle apparatus and materials of science.

4. The elementary science program should be an integral part of the school's K-12 program. The elementary science program should be viewed as a base for the total school science program.

5. The physical, biological, and earth sciences should be represented in each year of the elementary science sequence, and modern developments in the newer sciences and subsciences should not be overlooked.

6. Needless repetition of learning experiences should be avoided. When a general area is dealt with a second time, the approach should be different, and should contribute to the development of more refined concepts.

7. The areas of science should be developed in depth, the major limitation being the previous experiences and maturity of the pupils.

8. Science activities should be planned so that children learn to use some of the procedures that are characteristic of science in dealing with questions and problems.

9. The experiences in science should be planned so that children learn to use some of the broad, pervasive generalizations of science to interpret events and phenomena of their environment.

10. The people who are to implement a science program must have opportunities to gain a clear understanding of the program, and should be involved in the actual planning of the program.

The flexible dimension

In this dimension of the program there is excellent opportunity to relate the instruction to the non-science areas of the curriculum. Similarly, there is provision to deal with the needs, interests, and concerns of the pupils, and to give attention to the ever-present problem of individual differences. Necessarily, this phase of the program is very likely to vary from year to year, and from one pupil group to another, and long-range planning can only be effective in rather general ways.

The planned dimension

Jacobson and Tannenbaum [10] have provided rather detailed suggestions for the organization of this planned dimension of the elementary science program. In grades K-6 six blocks of subject matter are dealt with according to the following formula:

1. THE EARTH ON WHICH WE LIVE
   - Study of rocks—grade 1
   - Study of soil—grade 2
   - Study of weather and climate—grade 3

[8] Both the planned dimension and the flexible dimension.

[9] Jacobson, Willard J. and Tannenbaum, Harold E. *Modern Elementary School Science*. Teachers College Press, Teachers College, Columbia University, New York, 1961.

[10] *Ibid.*, pp. 40–126.

Study of the earth's changing surface—grade 4
History of the earth—grade 5
The earth's resources—grade 6

2. HEALTHY LIVING THROUGH SCIENCE
Foods we should eat—grade 1
Preventing the spread of disease—grade 2
Our ears and hearing—grade 3
Our eyes and sight—grade 4
Good nutrition—grade 5
Community sanitation and health—grade 6

3. THE EARTH IN SPACE
The earth and the sun—grade 1
Air and the atmosphere—grade 2
The sun and the planets—grade 3
Oceans and the hydrosphere—grade 4
Space exploration—grade 5
The Milky Way and beyond—grade 6

4. MACHINES, MATERIALS, AND ENERGY
Simple machines—grade 1
Heat and temperature—grade 2
Energy and energy sources—grade 3
Water and water supply—grade 4
Simple electronics—grade 5
Flight in air and in space—grade 6

5. THE PHYSICAL ENVIRONMENT
Study of magnets—grade 1
Fire and fire protection—grade 2
Sound and music—grade 3
Light and photography—grade 4
Electricity—grade 5
The materials of our environment—grade 6

6. THE BIOLOGICAL ENVIRONMENT
Animal life—grade 1
Plant life—grade 2
Living things and their environment—grade 3
Organization of living things—grade 4
Adaptations of living things—grade 5
Man's use of living things—grade 6

THE JUNIOR HIGH SCHOOL SEQUENCE

Students in grades 7, 8, and 9 often have their last opportunity to study a wide range of the sciences, and under existing conditions some of them will not enroll in a more specialized science course during their senior high school years. At the same time, various studies have indicated that a good many students make their initial career choices while they are in the junior high school, which suggests that the science sequence they encounter at this level has a relationship to guidance that should not be ignored. It is therefore indicated that the potential importance of the junior high school science sequence is considerable, and that it is the clear responsibility of science education to make the offering as effective as possible.

Clearly, the general science courses of the past decade will not serve the desired purpose, if for no other reason than that the establishment of strong elementary science programs makes them inappropriate. What is needed, among other things, is articulation with the program of the elementary school so that learning experiences proceed without needless repetition, and at each level the young people have opportunity to perfect or round out their concepts about science and the scientific enterprise. With these considerations in mind, Beck and Jacobson [11] have offered general suggestions for the development of more appropriate science programs in the junior high school, emphasizing that they should proceed from the science experiences of the elementary school, cultivate an understanding of the major concepts

[11] Beck, Alfred D. and Jacobson, Willard J. Chapter 7 in Fitzpatrick, Frederick L. (ed.) *Policies for Science Education.* Teachers College Press, Teachers College, Columbia University, New York, 1960.

and principles of science, deal with the subject matter in greater depth, and make special provision for students who display science-oriented interests and aptitudes.

Following this lead, Fischler[12] developed a recommended pattern for three integrated science courses for the junior high school. In outline form, this pattern is as follows:

Seventh grade—The Environment and Human Needs

1. THE EARTH IN SPACE: the Milky Way, the solar system, the earth, and new mechanisms for space exploration.
2. THE ATMOSPHERE: nature of the atmosphere, oxygen, carbon dioxide, the water cycle, air pollution, and weather.
3. WATER RESOURCES: physical and chemical characteristics of water, water pressure, water supplies, uses of water, and conservation of water supplies.
4. BIOLOGICAL RESOURCES: photosynthesis, foods, organic decay, the nitrogen cycle, and the balance in nature.

Eighth grade—Use and Control of Energy

1. THE STRUCTURE OF MATTER: states and properties of matter, atoms, molecules, chemical changes, acids, bases, salts, and common compounds and mixtures.
2. TRANSFORMATIONS OF ENERGY: the nature of energy, heat energy, radiant energy, magnetism, static electricity, current electricity, uses of electricity, and an introduction to electronics.
3. MAN AND MACHINES: distance, force, work, friction, mechanical advantage, power, heat engines, aero-dynamics, and flight problems.
4. THE BODY AND HOW IT WORKS: body framework, foods and digestion, circulation, respiration, excretion, and coordination.

[12] Fischler, A. S. *Modern Junior High School Science*. Teachers College Press, Teachers College, Columbia University, New York, 1961.

Ninth grade—Frontiers of Science

1. OUR ATOMIC WORLD: radioactivity, structure of matter, nuclear energy, applications of nuclear energy, radioisotopes, and radiation hazards.
2. FRONTIERS OF THE EARTH: structures of the earth, earth movements, ores and fuels, the oceans, and the polar regions.
3. MAINTAINING BODY HEALTH: disease organisms, body defenses, disease prevention, functional diseases, inherited diseases, and environmental effects.
4. SCIENCE AND CHANGE: science, technological applications, populations, transportation, and the scientific enterprise in the future.

THE SENIOR HIGH SCHOOL SCIENCES

In the same way that the junior high school science offering takes its departure from the science offerings of the elementary school, the senior high school sciences must be planned in the light of what students have studied in grades 7, 8, and 9. Moreover, there is the obvious fact that great advances in knowledge have made the older courses of study obsolete.

The program in biology

Recent years have witnessed notable additions to our knowledge of cellular physiology, including the DNA-RNA relationships and functions, the significance of ATP and ADP, the role of enzymes, the effects of growth substances, and further light upon the processes of photosynthesis and chemosynthesis. Meanwhile, we have learned more about the nitrogen cycle, chemotherapy, immunology, virology, and radiobiology, to list only some of the modern advances. In the Science Manpower Project program it was possible to include the newer materials by virtue of the fact that basic understandings needed to handle these materials are dealt with during the junior high school years.

The Science Manpower Project's recommendations for the tenth grade biology course were prepared by Stone,[13] and included study of the following topics:

1. CHEMICAL AND PHYSICAL ASPECTS OF LIFE: chemical and physical properties of protoplasm, the growth and repair of protoplasm, and the use of energy by protoplasm.

2. STRUCTURE AND FUNCTION OF LIVING THINGS: cellular structure and physiology, division of labor and increase in complexity, leading to a study of the more complex plants and animals.

3. INTRA- AND INTERDEPENDENCIES OF LIFE: chemical factors, physical factors, infections and functional disorders, and the natural and artificial defenses of the body.

4. REPRODUCTION: mitotic division, examples of asexual and sexual reproduction, cleavage, differentiation, and development.

5. GENETICS: Mendel's law, multiple genes, linkage, mutation, human heredity, and environmental effects.

6. CHANGING THINGS: the changing environment, origins of life, development of complex organisms, theories of natural selection, and modern problems of production and control.

The programs in chemistry

Like tenth grade biology, the offering in chemistry necessarily is conditioned by the facts that recent research has accounted for notable advances, and that a strengthened science program at the lower levels calls for proper articulation and makes possible greater study in depth. In one of the monographs of the Science Manpower Project, by Pierce,[14] the point is made that various unifying themes, such as the nature of atomic structure or energy transformations, may be employed to unify the basic course content. The following topics were set forth in the monograph on chemistry:

1. SCIENCE, MATTER, AND ENERGY: scientific methods; matter and energy; energy and the states of matter.

2. ATOMIC AND MOLECULAR STRUCTURE: the atom; the periodic classification of the elements; chemical combination and molecular structure; contributions of Gay-Lussac and Dalton.

3. CHEMICAL DYNAMICS AND EQUILIBRIUM: chemical dynamics; oxidation and reduction; chemical equilibrium; solutions; the colloidal state; electrochemistry, acids and bases; organic chemistry.

The program in physics

The third established science offering in the usual senior high school is, of course, the physics course, and, in this case again, there are problems of articulation and modernization of content. A monograph by members of the Science Manpower Project [15] deals with these problems, and recommends a program which features the following topics:

1. FOUNDATIONS OF MECHANICS: the problem of classical mechanics; Newtonian formulation of classical mechanics; applications of principles; basic assumptions of classical mechanics.

2. WAVE MOTION: origination of motions; dimensions of wave motions; similarity of wave types; the principle of superposition; resonance; diffraction.

3. HEAT ENERGY: kinetic theory of heat; equivalence of mechanical and heat energy; statistical development of kinetic theory; thermodynamics; radiant heat en-

[13] Stone, Dorothy F. *Modern High School Biology.* Teachers College Press, Teachers College, Columbia University, New York, 1959, Chapter 3.

[14] Pierce, Edward F. *Modern High School Chemistry.* Teachers College Press, Teachers College, Columbia University, New York, 1960.

[15] Science Manpower Project, *Modern High School Physics.* Teachers College Press, Teachers College, Columbia University, New York, 1962.

ergy; discrepancies in physical theory of heat.

4. THE NATURE AND PROPAGATION OF LIGHT: modern concepts of light and its propagation; interpretation of ordinary light phenomena; optical technology; sources of light energy.

5. ELECTRICITY, MAGNETISM, AND ELECTRONICS: basic concepts; important electrical phenomena; basic electrical devices; analysis and synthesis of secondary devices; important secondary devices.

6. NUCLEAR ENERGY: atoms, including size, atomic particles, structure, and electrical changes of particles; nuclear stability and radioactive decay; radiation detection.

7. RELATIVITY: Newtonian relativity; special theory of relativity; general theory of relativity.

8. RECENT ADVANCES IN PHYSICS: recent technological progress; overlapping science disciplines; testing theories at their limits; theories needed to unify data; areas in which data are grossly incomplete.

RELATED STUDIES AND REPORTS

As might be expected, not all of the project effort was concerned directly with course of study development. In addition, certain factors having to do with guidance, career selection, and teaching procedures received attention. The following reports of the Science Manpower Project belong in this category.

1. *A Guide to Engineering Education* [16] was designed to supply information about engineering education to high school science teachers and students they advise. It included recommendations for pre-engineering programs, a discussion of aptitudes, and descriptions of different types of programs offered by colleges of engineering.

[16] Eller, Frank W. *A Guide to Engineering Education.* Teachers College Press, Teachers College, Columbia University, New York, 1958.

2. *Dimensions, Units, and Numbers in the Teaching of Physical Sciences* [17] is a manual for the secondary-school science teacher, which includes discussions on how to introduce some of the quantitative aspects of science instruction.

3. *Problem-Solving Methods in Teaching* [18] includes general descriptions of problem-solving approaches to science instruction, and specific examples drawn from the areas of biology, chemistry, geology, and physics.

4. *A New Dimension in Biology Teaching: The Interpretation of Electron Micrographs* [19] makes available to the secondary school science teacher an analysis of procedures in electron microscopy, including the interpretation of electron micrographs. By studying a series of perhaps 500 sections made as a diamond chip passes through a single cell, it is possible to reconstruct the three-dimensional structure of the cell. Micrographs for analysis were included in the monograph.

5. *Attitudes of Certain High School Seniors Toward Science and Scientific Careers* [20] reported a study of 3057 high-school seniors, their tentative career selections in 1957, and their responses to 95 items of an attitude inventory having to do with science and scientific careers. The student responses were compared with responses made by a jury of scientists. Incidentally, the *Allen Attitude* inventory developed for this study has been used in studies at a number of universities.

[17] Ford, Renee G. and Cullmann, Ralph E. *Dimensions, Units and Numbers in the Teaching of Physical Science.* Teachers College Press, Teachers College, Columbia University, New York, 1959.

[18] Mills, Lester C. and Dean, Peter M. *Problem-Solving Methods in Science Teaching.* Teachers College Press, Teachers College, Columbia University, New York, 1960.

[19] Feldman, Dorothy G. *A New Dimension in Biology Teaching: The Interpretation of Electron Micrographs.* Teachers College Press, Teachers College, Columbia University, New York, 1962.

[20] Allen, Hugh, Jr. *Attitudes of Certain High School Seniors Toward Science and Scientific Careers.* Teachers College Press, Teachers College, Columbia University, New York, 1959.

6. *The High School Seniors: Two Years Later* [21] was a follow-up study of a portion of the population reported in the initial attitude study. In this follow-up study Allen determined the extent to which tentative career selections had changed after a two-year interval, and the degree to which responses to selected items of the attitude inventory had shifted.

A number of other studies related to the general effort of the Science Manpower Project were carried out by doctoral candidates at Teachers College, Columbia University. These candidates were not Fellows of the project, but their choice of studies was influenced by project activities, and their findings have significance in terms of maintaining a satisfactory supply of science manpower. They are not, however, reported in this analysis.

THE FUTURE

The Science Manpower Project monographs were designed as guides for curriculum revisions that are in turn effected by individual school systems.

The extent to which the Science Manpower Project's activities have influenced policy and curricula at local and state levels is difficult to estimate. The courses of study developed in several states and large city school systems have been designed along the lines suggested by the Science Manpower Project. Thousands of the monographs have come into the hands of superintendents, principals, curriculum supervisors, and science teachers. Initially, it was possible to provide complimentary copies to school administrators, but because of the large volume of requests, this is no longer possible.[22] It is perhaps fair to suggest that the Science Manpower Project was one of the forces that led to change and improvement in American science education.

Much, of course, remains to be done. It is becoming clear that a major limiting factor in the further development of science programs is the teacher. The task of preparing high quality teachers in sufficient numbers for all levels of education has barely been faced and hardly begun. The new technology that may make a different kind of education possible has not yet been tapped to any appreciable extent. The hardware is there, but the programs await creative science educators who can undertake the gigantic task of preparing them. Also, insufficient attention has been given to the role of science in our society. There is a need for creative approaches to the development of policy and curricular programs that will help the next generation to use science more effectively in our changing society.

The task of improving science education is never-ending. There probably is no one best way to develop a science program. Instead, a variety of programs and approaches to teaching are needed. The Science Manpower Project was the result of an idea and a desire to do something. By today's standards the Project operated with relatively little support, and almost all of this support came from enlightened industrial firms and foundations. We hope there will continue to be room for variety in the attempts to improve science education, and that others who have an idea will seek support and try to transform that idea into action. Essentially, this is what the Science Manpower Project did.

[21] Allen, Hugh, Jr. *The High School Seniors: Two Years Later.* Teachers College Press, Teachers College, Columbia University, New York, 1961.

[22] Copies are still available, however, from the Teachers College Press, New York, New York 10027 at modest cost.

THE SUCCESS OF RECRUITED STUDENTS IN A NEW PHYSICS COURSE *

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Introduction and Problem

The concern of science educators and others over declining enrollments in physics has led to the development of a new physics course called Harvard Project Physics. One of the aims of this course is to "create a set of materials that may help check the continuing drop in the proportion of students who are taking physics in high school." [1] In order to achieve this aim, the course has been designed to "catch the interest of the large, untapped group of students who now do not enroll in a physics course at all. . . ." [2]

The present study is an evaluation of the new course in terms of its appropriateness for those students who normally do not take high school physics. Specifically, we wanted to:

(1) determine the characteristics of a group of students recruited (recruits) into a physics course by teachers and counsellors

(2) compare the observed changes of the recruited group with the observed changes of those students who had decided to take physics of their own volition (regulars).

The Sample

Approximately 40 physics teachers were selected from a list of several hundred volunteers to teach Project Physics during the school year 1966–67. These teachers agreed to cooperate in an evaluation of the course by administering a series of pre, mid, and post tests to their students. The purpose and design of the general evaluation is described elsewhere by Welch and Walberg. [3]

The teachers were asked to invite a number of students who had chosen not to take physics to try the new course. The method of selecting the recruited students varied from school to school. In most instances, teachers explained Project Physics to students and asked them to reconsider their decision. In other schools the guidance counsellors made the selections. A total of 194 students accepted the invitations and comprise the group of "recruited" students of the study. This represents 10 per cent of the total number of students in the 38 schools for which complete test data are available.

The Criteria

Several different tests of achievement, interest, and attitude were used to describe the characteristic of the recruits and to detect any changes resulting from their one-year study of the course. The achievement measures included a Project-developed Physics Achievement Test (PAT), the Test on Understanding Science (TOUS), and the Welch Science Process Inventory (SPI). A Pupil Activity Inventory (PAI) was used to infer interest through participation in a series of science activities. From the six sub-scales, two, Academic (doing school science kinds of activities) and Tinkering (science hobby activities), were used in this study. A sample item from the Academic scale is "Looked over the science books in libraries" and an item from the Tinkering scale is "Built or repaired radio sets or other electronic equipment because I am interested."

A version of Osgood's Semantic Differential technique was used to determine changes in attitude toward the concepts Physics,

* This study is part of the research and evaluation program of Harvard Project Physics. The authors wish to thank Herbert J. Walberg and Fletcher G. Watson for comments on an earlier draft of the paper.

Doing Lab Experiments, and Myself as a Physics Student. These tests were administered before and after the course and simple differences were computed separately for the recruits and the regulars.

Two other instruments, the Henmon-Nelson Test of Mental Ability and a Student Questionnaire, were also used in the study but were not used as measures of change. The Student Questionnaire was used to determine degree of satisfaction with the course. In addition, course grades were obtained for all students. A complete description of each of the tests listed above is available from the authors.

Procedure

The pre and post tests were administered to all students during the academic year 1966–67. Data were gathered using a system of randomized data collection within each class which maximized the number of tests and minimized testing time for individual students. [4] Under this system a random half of each class took one test while the other half of the class was taking a second test. Thus, one-half of the students took any one test, and one-fourth (½ x ½) of the students took the same test before and after the course.

Means on the pre-test and simple pre-post test differences were computed for each of the two groups. Differences between the groups were examined using t tests and confidence intervals.

Results

Table I summarizes the measured differences between the recruits and regulars at the beginning of the year. As one would hypothesize, the recruited students had lower scores on the Physics Achievement Test (PAT) and on the Henmon-Nelson test of mental ability. They had participated in fewer academic-type science activities (PAI). Also, they considered the semantic differential concept Doing Laboratory Experiments less simple and less fun, and saw Physics as less interesting and less safe. On the semantic differential scale, Myself as a Physics Student, the recruits saw themselves in this situation as less pleasurable than did the regulars.

On three of the pre tests, differences between the two groups were not statistically significant. This occurred on measures of general understanding of the nature of science (TOUS), knowledge of scientific processes (SPI), and frequency of participation in science tinkering activities (PAI).

TABLE I

Pre-Test Means of Recruits and Regulars †

Test	Recruits Mean	Recruits S.D.	Regulars Mean	Regulars S.D.	Difference	T Value
TOUS	32.0	3.5	33.4	3.3	−1.4	−1.66
PAT	16.0	4.3	18.0	5.1	−2.0	−3.74***
SPI	103.1	12.0	103.1	13.2	0.0	0.0
Pupil Activities						
—Academic	12.8	7.2	15.5	8.5	−2.7	−3.00**
—Tinkering	12.0	7.4	13.1	7.9	−1.1	−1.24
Doing Lab Experiment						
—Simple	27.7	8.7	30.2	8.7	−2.5	−2.61**
—Fun	31.7	8.8	33.4	7.4	−7.1	−2.00*
Physics						
—Interest	34.2	7.8	36.2	6.9	−2.0	−2.54*
—Safe	31.2	6.5	33.1	6.7	−2.0	−2.66**
Myself as a Physics Student						
—Pleasurable	35.4	8.6	38.4	7.4	−3.1	−3.76***
Henmon-Nelson IQ	108.0	13.2	115.5	15.1	−7.4	−3.10**

† The N for the recruit group on the pre tests is approximately 95, while the N of regular group is approximately 800. There is slight variation among tests because they were given on different days.
The asterisks indicate the level of significance: * $p < .05$, ** $p < .01$, *** $p. < 001$.

On the basis of the pre tests, it seems reasonable to conclude that the recruits as a group showed less interest and ability in physics, and were, in fact, different from those students who normally enroll in a physics course.

The second problem of the study was to determine the observed changes of the recruits and to compare these with the observed changes of the regulars. The pre test scores were subtracted from the post test scores to yield change scores for each group. Then the change scores for the two groups were compared statistically. Change scores and differences in change scores are reported in Table II. An observed difference of zero implies that both groups changed equally. If the difference is positive, the recruits gained more; if the difference is negative, then the regulars gained more.

Examination of Table II reveals that the the observed mean change of the recruits was either equal to or greater than the observed mean change of the regulars on 9 of the 10 tests. Only on the Tinkering scale did the regulars gain more than the recruits. However, two important points must be kept in mind. First, difference scores are usually unreliable. This is reflected in the rather large standard error associated with each observed difference. Second, in several instances, the apparent success of the recruits is not due to the fact that they gained more, but that they lost less (for example, note the Academic scale and Physics-interest scale).

On the Doing Lab-Fun scale, we may reject the null hypothesis that there is no difference between the mean change of the two groups. Apparently, the recruits found doing lab more fun than they expected at the beginning of the year, while the regulars, perhaps as a result of some disillusionment, showed a decrease on the scale. Thus, on this one test it is possible to state that recruits gained more than the regulars ($p < .05$).

Since failure to reject the null hypothesis on the remaining 10 tests does not necessarily imply that the groups gained equally, a further analysis was performed. Ninety-five per cent confidence limits for the differences were computed to give an indication of the true differences. These are shown in Fig. 1.*

The x's in the figure indicate the observed differences between the recruit mean change and the regular mean change. The lines represent the 95 per cent confidence

* The null hypothesis of no difference is rejected at the 95 per cent level where the confidence interval does not span zero. This occurs only for the Doing Lab-Fun scale in the present study.

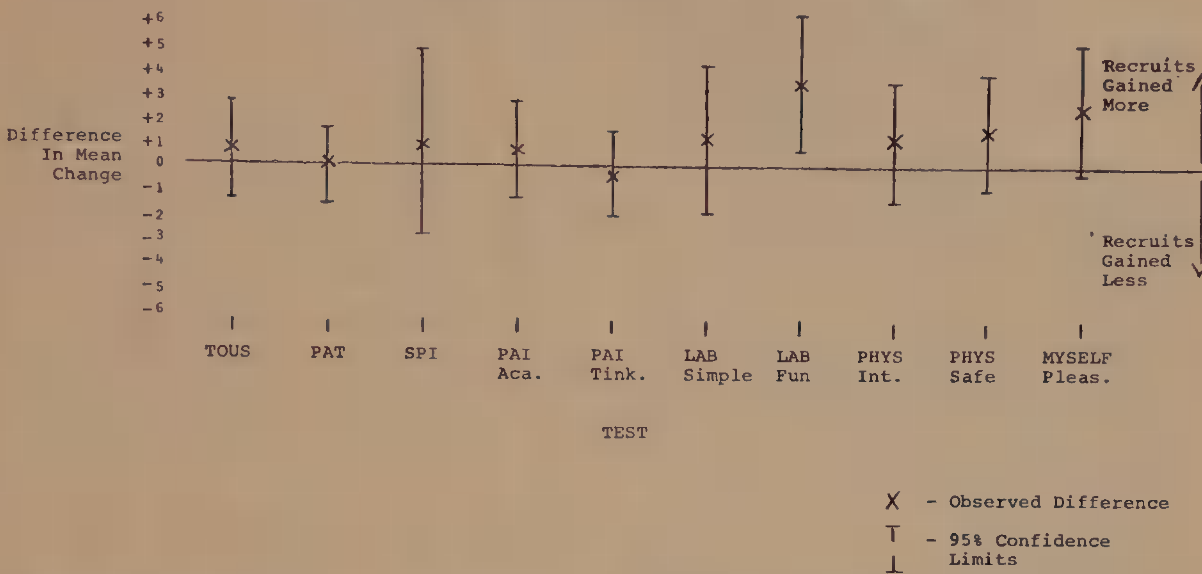
TABLE II

MEAN CHANGE SCORES OF RECRUITED AND REGULAR PHYSICS STUDENTS †

Test	Recruit Change	Regular Change	Observed Difference	Standard Error of Difference
TOUS	+3.7	+3.0	+0.7	1.0
PAT	+7.0	+7.0	0.0	0.8
SPI	+6.4	+5.5	+0.9	2.0
Pupil Activities				
—Academic	−0.8	−1.5	+0.7	1.0
—Tinkering	−0.9	−0.6	−0.3	0.9
Doing Lab				
—Simple	+0.5	−0.6	+1.1	1.6
—Fun	+1.8	−1.6	+3.4*	1.5
Physics				
—Interest	−1.1	−2.2	+1.1	1.3
—Safe	+1.0	−0.5	+1.5	1.5
Myself as a Physics Students				
—Pleasure	−2.2	−4.6	+2.4	1.4

† The N for the recruit change is approximately 45. The N for the regulars is approximately 300.
* Difference significant at the $p < .05$ level.

Fig. 1. Differences in mean changes of recruits and regulars.



limits of the differences. The chances are 19 out of 20 that the true difference is spanned by the interval. For example, on the PAT test we are 95 per cent certain that the interval —1.5 points and +1.5 points contains the true difference between the mean changes of the groups.

In general recruits gained slightly more than the regulars, and in no instance did the regulars do significantly ($p < .05$) better than the recruits.

Two other pieces of information obtained in this investigation pertain to the success of the recruits in this physics course. The first of these was the mean grade for each group. The mean course grade for 148 recruits for which this information was available was 2.44 on a four-point basis. For 1138 regulars, it was 2.54. The standard deviation for both groups was 0.45. The difference is not statistically ($p < .05$) significant. Both groups had mean grades in the C+, B— range. This lends support to the claim of some people that it is difficult to get good grades in physics. This is especially apparent when one considers that the mean IQ of the group (approximately 115) is near the 80th centile for high school seniors. The grade distributions showed 46 per cent of the recruit group receiving A's or B's while the percentage of regulars receiving A's or B's was 51 per cent.

Finally, a random sample of both recruits and regulars was given a student questionnaire. One of the items was "I would recommend this course to my friends." Seventy-three per cent of the recruits and 69 per cent of the regulars expressed agreement with the statement.

Thus it appears that students recruited in the Project Physics course gained as much or better than those students who signed up of their own volition. Gains on achievement measures, attitude and interest change, course grade, and an expression of satisfaction with the course were similar for both groups. The results are encouraging in terms of the expressed aim of Harvard Project Physics to help check declining enrollments in secondary school physics by designing a course that is appropriate for the group of students who now do not enroll in a physics course.

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2. *Ibid.*, p. 4.

3. Welch, Wayne W. and Herbert J. Walberg, "A Design for Curriculum Evaluation," *Science Education* (February, 1968).

4. Walberg, Herbert J. and Wayne W. Welch, "A New Use of Randomization in Experimental Curriculum Evaluation," *School Review* (Winter, 1967).

A SELF-INSTRUCTIONAL LABORATORY FOR SCIENCE TEACHERS

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It has been stated with great frequency that elementary school teachers are reluctant to use the science teaching equipment available to them because they are afraid of making mistakes. This is very likely true. Secondary school science teachers probably are not very different in this regard. The cause of this reluctance must include the simple fact that the unfamiliar and unknown are generally fear-inducing.

It is quite well established that elementary school teacher education programs do not include a high level of science preparation; and, as a consequence many articles of equipment and many science techniques are unfamiliar to the teachers. In spite of their greater depth of preparation in the subjects they teach, high school science teachers are not adequately prepared to use all the scientific apparatus which might be found in their classrooms and laboratories. Neither are they trained in the technical skills associated with this equipment in the demonstration and laboratory aspects of instruction. The reasons for this are undoubtedly numerous and varied. Certain to be involved is an ever increasing number of college science courses for which no laboratory instruction is provided as well as an increasing number of courses where the apparatus used in the laboratories is not of the type found in high schools.

This problem was recognized by the designers of all the National Science Foundation sponsored courses and by others involved in curriculum projects. In essentially all such efforts to provide more effective science teaching, it was deemed necessary to provide for direct contact with and instruction in instrument and equipment operation as part of the in-service programs for preparing teachers for these courses.

Surveys conducted by the authors in their science education courses at the University of Minnesota provided data which supported the findings of Beisenherz [1] in both the physical and biological science areas. He found that both on-the-job and pre-service biology teachers were deficient in their ability to exhibit some 100 skills, such as using a pH meter, the kymograph, the oil immersion microscope, staining microscope slide material, and demonstrating electrophoresis. Biology professors at the University of Minnesota recognized the values of these skills but also indicated that only a few of them were taught in the courses required of all prospective biology teachers. It must also be noted that the College of Education at that time had neither the facilities to carry out such instruction nor a feeling that it should be its function.

At science education centers such as those to be found at the University of Illinois, The Ohio State University, Michigan State University, and Florida State University, a supply of apparatus is made available to teachers-in-training and in-service teachers. Hence, the opportunity to develop some skill in the use of equipment is thereby fostered and facilitated. In most instances no formal instruction is provided and quite frequently only the manufacturers' instruction sheets, if available, are provided to assist the learner.

At the University of Minnesota, under the auspices of the Upper Midwest Regional Educational Laboratory, (Grant #22-B-FP003), a somewhat different approach was originated and is now in the second year of operation. A Self-Instructional Science Demonstration Center (the formal name of the operation) under the co-direction of the authors was designed, equipped, and staffed. In its operation the laboratory resembles the audio-tutorial pattern of Postlethwaits' botany laboratories at Purdue University.

The laboratory was constructed by re-

modeling a 30 x 32 foot science classroom in Peik Hall, the University of Minnesota laboratory school. The tops of tables located in the center of the room were fastened together and then, along with perimeter counters, were provided with pegboard backs and sides connected into carrels. The carrels ranged in width from 18 inches to 3 feet and in length from 5 to 7 feet. Each of the study spaces was provided with the necessary equipment, supplies, and printed directions for teaching some skill or technique. In some instances, printed directions were supplemented with 8mm sound or silent loop films, audio tape recordings, or 2 x 2 slides. Prefabricated kitchen cabinets were used to provide storage space for unused units. Sixty-one teaching units, each with apparatus and directions are now available for use. Since but twenty carrels are available, the laboratory is changed for each university quarter with all science areas being represented each term.

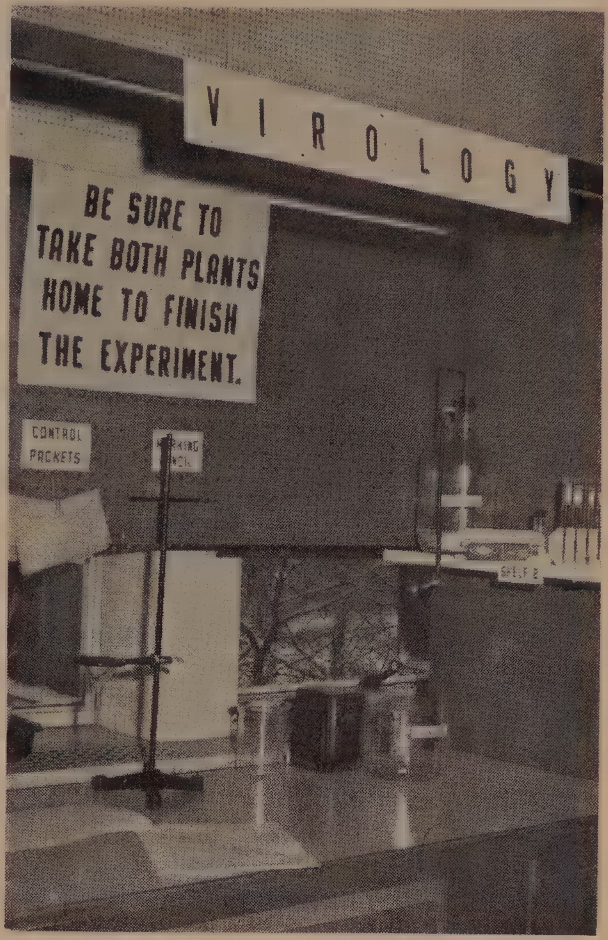
The laboratory is open all day each class day for pre- or in-service use. Individuals use the facility at the times which are most convenient to them. A staff of five quarter-time teaching assistants provides constant maintenance and supervising services as well as a teaching function when needed by students.

The list of teaching units below has been arbitrarily divided by science subjects. It should be recognized, however, that many of the units are usable in more than one discipline. The centrifuge, balance, chromatography, and colorimetry units illustrate this point. The cost of each unit varied from less than a dollar for equipment to as much as three hundred dollars. The time required for the student to complete the work at a carrel was about 45 minutes.

The following list by subject area is suggestive of the kinds of instruments and techniques available for in-service and pre-service teacher to learn:

BIOLOGY

Isolation of Bacteria
Staining Bacteria



Antibiotics
Thin Layer Chromatography
Tobacco Mosaic Virus
Enzymology
Paper Chromatography
Culturing Slime Molds
Plant Hormones and Growth Factors
Kymograph
Chromosome Staining
ATP and Muscle Contraction
Blood Typing
Volumeter
Electrophoresis
Test Solutions for Nutrient Identification
White and Red Blood Cell Count
Stethoscope and Sphygmomanometer
IMPScope
Microprojector
Warburg Apparatus
Germination and Light

METEOROLOGY

Meteorological Instruments
Weather Mapping
Nephoscope

ASTRONOMY

Measuring Diameters of the Sun and Moon
Sextant
Planetarium

CHEMISTRY

Spectrometry
Decade Scaler
Cloud Chamber and Brownian Motion
pH Meter
Electrical and Dial-O-Gram Balances
Monomolecular Layer
Use of Vertical Overhead in Chemistry
Column Chromatography
Factors Affecting Chemical Reaction Rates
Colorimetry
Electrochemistry
Centrifuge

PHYSICS

Stroboscope
Optical Disc
Oscilloscope
Ripple Tank
Volt-Ohm Milliammeter
Determination of "G"
Interferometer
Conservation of Momentum
IPS Assortment
Electron Properties
Gas Laser
Microwave Generator
Electrostatics

GEOLOGY

Measuring Circumference of the Earth
Properties of Earth's Materials (Porosity, Permeability, and Capillarity)
Contour Mapping
Three Dimensional Modes of Rock Formations
Stream Table
Coal Ball and Limestone Peels
Soil Assay
Hardness and Other Properties of Minerals

Before the laboratory was opened for use, the first set of twenty teaching units was given a trial run by science teachers from the immediate metropolitan area. These teachers provided some excellent constructive criticism and were generally enthusiastic in their support of the facility. The first class of prospective teachers to use the laboratory were equally supportive. Their suggestion that it be used as part of their science methods course, one required of all teachers, was accepted and put into operation.

Teachers-in-training have made good use of the laboratory. Each trainee used the materials of the carrels which he felt would satisfy his needs. On the other hand, there has been less than expected use of the facility by in-service teachers. Perhaps it is asking too much to have teachers give of their own time to use these materials without credit being given, even though no fees are collected. It has been planned that a sequence of summer school courses be given in which the units, of say the physical sciences, be presented as laboratory activities coupled with class discussions in which plans would be formulated for putting the newly acquired skills and knowledge into teaching materials and methods for use in high schools.

Extension of the kind of facility described here into the preparation of elementary school teachers of science seems to be highly desirable and urgently needed. It seems reasonable that any college could provide such an instructional program as this for both elementary and secondary school teachers. While a specially designed room would be highly desirable and advantageous, it would not be absolutely necessary. A single carrel or more could be set up in almost any science laboratory. In fact, a carrel could be so portable as to be set up in any kind of classroom. Frequent changes in the materials of the carrel would, over a period of time, provide the essential service the students need. It is also reasonable to consider the possibilities of an in-service facility as being provided by a large school district for its staff or use in science education centers sponsored by state departments of education.

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IMPLICATIONS OF STRUCTURE FOR ELEMENTARY SCIENCE

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I'd like to begin by showing you where my concern lies. If I could just take you back to the three Yearbooks devoted to the teaching of science, published by the National Society for the Study of Education, you will soon be aware of this concern. For the sake of discussion, let's begin with the 31st Yearbook authored by some of the pioneers in our field such as Powers and Craig. This Yearbook stated that the structure of science consists of two facets: one, the "big ideas"; two, "problem solving." By getting youngsters involved in a series of carefully selected problems which related to some "big idea," pupils could engage in elementary school science profitably.

Approximately fifteen years later, the 46th Yearbook appeared. As one aspect of the structure of science, the big ideas were changed to "major generalizations." Children should encounter science, and the way to do this is to get the pupils involved in "scientific thinking." What were the major generalizations? ——The same as the big ideas. What was scientific teaching? —— Getting youngsters involved in a science problem.

When the 59th Yearbook came out, we found that we no longer teach for major generalizations, but rather for "conceptual schemes"; we don't do this through scientific thinking but rather through "inquiry." What are these conceptual schemes? —— The same notions as the big ideas. They include evolution in biology, conservation of matter and energy, dependence of living organisms on a total environment, the expanding and changing universe.

It would seem that we haven't changed our *approach* to science very much after all. All we're doing is changing the nomenclature. If we're not careful, all we may do in the new science programs is change yet another label. This, in essence, is one of the concerns I see on the horizon at the present time.

SCIENTIFIC ENTERPRISE

We need to look at the nature of the scientific enterprise in its broadest context. In

order to do this, let us start with an observation made by a scientist. What kind of observation are we talking about? Let me illustrate. I observe everyone in a room and I don't see any event in the room that makes me challenge my concept of what a human organism ought to be. I don't see anyone who is doing something "abnormal" in terms of my concept of what a human being ought to be doing. Therefore, nobody here really concerns me scientifically at the moment. What kind of an event am I talking about then? I'm talking about the observation of an event which doesn't fit the conceptual model we possess. Psychologists call such events, *discrepant events*. They are discrepant because they're different from what we expected.

Let me illustrate a discrepant event in the training of some prospective elementary school teachers. During a two-hour class session, my prospective teachers became fully convinced that every time heat energy enters an object, the object will expand. They were convinced because they spent the two hours observing this phenomenon occur by utilizing the bi-metallic strip, by checking the coefficient of expansion of heat and by using the familiar ball and ring. All these activities were somewhat related to the notion of the kinetic molecular theory. When I was fully convinced that they thought they could explain any expansion and contraction by this theory, I asked them to explain a temperature-volume graph for water. What the water graph tells us is that as the temperature decreases, the volume also decreases. Wonderful! We can explain this very nicely with what we have learned *but*, when we reach 4 degrees Centigrade, the substance suddenly expands, even though it's going from 4 degrees to 0 degrees Centigrade. Since temperature is the average amount of heat an object possesses, the heat content will have to continue to decrease. I left them with this for a short while and then asked what explanation they could give. It is interesting that the explanations given by students at the level of the graduate school are about the same as those of pupils in the third and fourth grades. They will tell you that what happens is that as molecules contract they are losing energy all the time, they're changing and are now forming solids or crystals. The result is that they capture air and expand because they haven't enough energy to push the air out. The problem with the water is the same and so it expands.

When you get to that stage, you point out that since you have X amount of molecules which weigh A, then X plus air ought to weigh A plus the weight of the air because everybody knows air has weight. But we know that ice floats, so that it must be lighter by volume than the same volume of water. The result is that their reasons are not correct.

I use this merely as an illustration because I don't expect the students to discover the reason for this immediately nor is that important to me at the moment. What is important is that by introducing this kind of an event, after they have been walking down a path which they think is perfectly logical, you force them to come to grips with the *concept* and with the new event. Let me offer the following hypothesis just for discussion: the job we have in teaching science is nothing more than carefully sequencing these discrepant events.

PSYCHOLOGICAL THEORY

If we look at Piaget, as a representative illustration of a large group of psychologists both in Europe and the United States, one can ask the question—once we've introduced the discrepant event what does the child have to do? It appears that the child has to go through three processes: assimilation, accommodation, and equilibration. The child must carry these on for himself. We cannot do it for him.

The first thing he has to do is make sure that this event is, in fact, so. He has to be convinced. This bears upon the notion of repetition. The search is to see whether in fact it occurs all the time, most of the

time, and under what conditions. So he must spend a lot of time, if he is playing with this little problem, putting water in the refrigerator, measuring the increase in volume and seeing that every time ice freezes, it does occupy a greater volume. First comes the reproducibility of the event.

It's important (in terms of the child) how far the discrepant event is from the child's previous experience. If he has never had any experience with this, then he isn't even aware there is a problem. He does not have any conceptual model against which to look at the event. On the other hand, if we introduce a discrepant event which *we* think is discrepant, but for which the child can account intellectually, it's no problem either. If we are too far away, we produce nothing. If we are in synchronization, if we are in harmony with what the child knows, then he hasn't any problem.

The job of sequencing these events is not easy and it is different for different children depending on their experience and background. To see that an event is discrepant, the child has to have some comprehension, and even the child who comes to us at age five or six has some comprehension about the world. The job we have is to move him from where he is, carefully, and sequentially, so that he ends up with a model which will enable him to function in the world.

We know the sun is shining even if there isn't any sun visible today. Though we do not see it, we have confidence that it is there. Why? We have a model which tells that even though today it is snowing or cloudy, the sun is there. We operate with this model all the time. The child has to develop such a model. Then he has to alter his model to take the discrepant event into account.

Once he has convinced himself that the event is in fact so, then he must accommodate his model to take the event into account. When he has successfully done that, he reaches the point of equilibration. He is now happy that the newly formed model or the revised model can bring this event into harmony with what he knew before. At that point, our job is to introduce a new discrepant event.

This procedure is based on the theory that an animal does not learn if it is complacent. The job we have is to introduce just enough frustration so that the "animal" is motivated intellectually to want to go back to equilibrium. This is my frame of reference when I speak about observation and how it relates to the whole structure of science.

EXPERIMENTAL FACTS

In the scientific enterprise, the scientist is always making observations but he does more than that. He tries to go from the observation to some kind of hypothesis (or intelligent guess) which is testable. In education, this is our biggest problem. We have yet to learn how to go from gross observation to a statement which is testable. I recently reviewed a new health guide where there was an objective such as, "to develop an appreciation for the body." How can I ever know how to measure a student's ability to appreciate the body? What do we look for? The scientist doesn't have this problem. If he wants to know the effects of a 3/10 molar solution of adrenalin on the gastronemous muscle of the frog as it affects tetanus reaction, then what he wants to know is extremely precise. He gets the gastronemous muscle of the frog and he puts his three drops of 3/10 molar solution under certain temperature conditions and he sees what effect this has when he stimulates it electrically.

We have to begin to come to grips with what it is we want to measure in education and then see what we can do about measuring it. If we really can't measure it, maybe we ought to keep it out of our guides. To be more specific, if we teach for what we look for, we have 100 per cent validity. Therefore, we must work our objectives in behavioral terms so that we can look for what we are teaching for.

When the scientist makes the observation, and frames his hypothesis, he performs an experiment which leads to some experimental fact. Here's where the difficulty in elementary school science lies. We teach the facts as though the rest of the process doesn't exist. Yet, the most crucial thing in science is the *process* and not the fact. When I studied Chemistry I, I was taught that Xenon does not react. I am sure that if I had gone to my professor and said I wanted to do a Ph.D. study to see if Xenon reacts, he'd have sent me home to come back with another problem. There was no doubt in my mind that Xenon didn't react. Yet today, we find that under certain conditions Xenon does react. What other *facts* did we learn? In Biology, we were taught that man has 48 chromosomes. In Physics, we studied a pretty static model of the electron going around a nucleus which contained a neutron and a proton.

If I were a good, divergent thinker, and if I had questioned the teachers as to the degree of "truth" associated with the statements, chances are I would never have had the opportunity of being here. But, I was a "good, obedient, cheerful, brave, thrifty," etc. student. I memorized whatever was told to me and I did it within the time limit given. I got my B's and an occasional A and I proceeded through school.

All of the above information was memorized and what bothers me today, and the reason I am taking this attack, is that no one ever told me that maybe it was wrong. Maybe it will eventually be proven wrong. It was taught to me as though it were absolute. There was no probability associated with any of the statements and none of the parameters were looked at.

What I am suggesting is that in the teaching of elementary science, it's important to give the pupils the feeling that under conditions A plus B plus C, you will get D, but under conditions A prime plus B plus C, you may not get D. Just alter one condition, change the acidity of the soil, and you end up with different organisms present in the soil. The way that the scientific fact is associated with this process has to be understood. We have to begin to teach it in this manner.

THE FLUIDITY OF SCIENCE

The whole nature of the scientific enterprise keeps moving and if science itself is ever-changing, how does it ever go forward? Its success depends on external reliability and validity, as well as internal reliability and validity if one looks at the total enterprise. The nature of this reliability and validity lies in independent verification, which is what keeps the enterprise "honest." The scientist must publish. He publishes for a variety of reasons, and one of which is to make a contribution of his small experimental fact to whatever is going on. More important, he "*picks the brains*" of his colleagues. If you read the discussions in science literature, you find that he often grossly exaggerates what he found (in his discussion section) in order to create a dialogue.

In education we haven't worked this way. In education (and I am in education so I can talk this way and criticize myself) no experiment has ever failed. I have never witnessed one article in the literature where somebody took the time to write up something which gave him negative results from his predicted outcome. This doesn't happen in education. What is worse, we haven't even a place in most of our educational literature for a truly honest discussion to take place.

When I did my own research at Teachers College, Columbia University I went back to the General Science Quarterly and I was delighted with the verbal battle that was taking place between Professor Palmer at Cornell University, who represented the Nature Study Movement, and Professors Craig and Powers, who were the forerunners of modern day science. Each month there was an article in the journal present-

ing one point of view and the next month answered by a colleague. This is currently missing in science education.

The results of the 3/10 molar solution of adrenalin on the gastronemous muscle of the frog is written objectively, but in discussion, the implications are exaggerated. However, someone writes in the "Letters to the Editor" section, "But Sir, when you try the adrenalin on the heart muscle it reacts in just the opposite way than it does on the gastronemous muscle of the frog." So maybe I will begin to study the area more carefully, and this is what keeps the nature of the enterprise in science moving forward.

In addition to the internal enterprise, there are also the engineering and external aspects. We are now listening to the heavens instead of just looking at the heavens, and we have radio-astronomy emerging as a discipline. We have biophysicists emerging along with oceanographers. We now have the electron microscope plus photography giving us an opportunity of a million magnifications so we don't teach about genes and chromosones but, rather about RNA and DNA. Why? New techniques, new instruments, new observations, new hypotheses, new experimental facts, new designs and new models. This in essence is what I would like to call the structure of science in totality. This is the structure of science as an enterprise.

TEACHING OF SCIENCE

If we want youngsters not to become scientists, but just to become scientific literates, then we have to give them the opportunity to proceed in this way. What I am pleading for is TIME, time to allow them such opportunity. Let me illustrate this with one example from the Science Curriculum Improvement Study. In this particular study, the writers spent one full year in the first grade working with first graders on material objects, properties of objects which enable pupils to categorize and make order out of chaos. After the pupils played with the different size, shape, texture of small sets of buttons, they were given a whole box of buttons. The problem was to see how many different ways they could categorize the buttons. The teacher said to the youngsters, "Here is a pile of buttons. See how many different ways you can group these buttons so that we can guess what property you have used." How do we evaluate the pupils? The teacher has some other buttons in his pocket and when he sees that the youngster has four or five ways of classifying he stops and says, "Now where would you put this button?" If the child understands the order and if it doesn't fit into any of his piles, he places the button in a completely separate pile. He might say, "I'm going to start a new pile with this button because it does not fit any of the others."

Later on the term "object" is expanded to include living organisms.

The SCIS project spent a year doing nothing else but giving pupils experience with the notion of property, differentiating property from use, and giving them opportunities to categorize and order. They do this in the biological, in the physical, in the geological, in anything that they can manipulate both man-made and natural. They have plastics as well as metals and nonmetals. They use various types of cloths; linens, silks, cotton, as well as synthetic fibers. They do this because the next aspect of the model is to introduce or invent the notion of "system."

The notion of system is crucial and fundamental in science. No scientist looks at the total world. Scientists look at systems, definable systems. The child does not discover this, by the way. A system has to be invented. We, the teachers, have to invent the notion of systems and then we have to give the pupil the opportunity to assimilate and accommodate the notion and feel very comfortable using it, so that when we are no longer with

him he is constantly utilizing the concept of a system. He never forgets it and we don't have to re-teach it over and over again because the understanding is usable at his level of operation.

I can define the system in this room very easily—it's the human beings present. This is the system in which I am interested—nothing else is relevant at the moment. The child has to realize that one must define a system and then be able to look at the objects in the system to determine whether there is evidence of interaction. This should be introduced very early, and a great deal of time spent giving the youngsters ample experiences with the concept. Again, SCIS works both in the geological and biological areas of science wherever they can find good concrete illustrations of the notion of a system.

A look at all of the new science programs indicates an activity-oriented approach toward the development of some fundamental notions, activities which are carefully sequenced and which have a great deal of involvement for the pupils.

Probably you have seen the large scope and sequence charts of any textbook published, the big charts where they show the sequence of concepts every year. Every elementary school textbook series has one. If this is all we are talking about, then we have had it for all of these years. I'm suggesting that we haven't had it because we have never organized it and we've never given youngsters time to learn.

Let me illustrate this by one piece of research. Professor Smedslund of Sweden took children of ages six through eight and used one of Piaget's experiments. Piaget had experimented with plasticine (clay) balls. The youngsters are asked if two balls are the same. They feel them and say "Yes." You ask the youngsters what would happen if the balls were put on the scale. Those who understand what "same" is predict that the scale will balance. When the experimenter puts them on the scale and it does balance, he goes on to say, "If you take one ball and change its shape, what will happen to the scale?" Some youngsters who have learned conservation of mass or substance will say it will still balance. Most youngsters about age six will *not* say it will balance. They believe if they change the shape of the ball it will either be heavier or lighter, or this side of the scale will go down or up depending upon what dimension they look at.

Smedslund proceeded by dividing a group of thirty children into two groups; one group which could predict successfully that if you change the shape of an object you don't alter the content or mass, and a second group which could not. He tried to teach the second group to conserve by his manipulating objects in the classroom until they were capable of predicting accurately three times in a row what would happen when he changed the shape of an object. Then he brought the total group together and he tried what in psychology is called "extinction." As he changed the shape of the plasticine ball, he took a piece away. The children didn't see him do this and when he asked them what they thought would happen when he put it back on the scale, they predicted it would balance. When he put it back on the scale, of course, it did not balance. What Smedslund wanted to see was what kind of arguments the children would offer. The children he taught said, "That's interesting," or "It didn't happen that way when you did it in class." Some said, "Do it again." So he did it a second time and it didn't balance again. They said, "Well maybe sometimes it balances and sometimes it doesn't." But the children who had acquired the concept of conservation through experience and maturation said, "You are cheating." "The scale is no good." "Do it again, I want to watch more carefully." They were not about to alter the model they had acquired on the basis of this little evidence.

What are we teaching the children who can't conserve? (The majority of children ages six and seven) We're teaching them

such things as the earth is a round sphere, it's tilted on an axis, it's rotating at a thousand miles per hour which is why we have day and night. We're asking the second grader to intellectualize those notions which we can hardly comprehend at this particular time. Can you comprehend that this earth is turning at a thousand miles per hour? Could we comprehend that the earth is tilted on an imaginary axis? Yet, even the 1965 editions of elementary science books introduce the study of astronomy, the causes of day and night, and the causes of seasons at the second grade level. Since pupils cannot comprehend it, what do we do? We teach this every single year. Why? Because they couldn't comprehend it in the second grade, we repeat it a little bit more in the third grade, and a little more in the fourth grade, fifth grade, sixth grade, and even in the seventh grade.

What I am suggesting is that the time has come for a reorganization which is entirely different from what we have at the present time. The reorganization to which I refer is the selection of two or three fundamental ideas each year which are taught thoroughly, until the pupil reaches equilibrium with the new idea. Then let's leave it alone! If the pupils have a model, they will be utilizing the model daily and will not forget the idea. What Thorndike's studies have indicated is that we'll forget the little facts but we will not forget the model of a larger system. If the child has a model, such that when he looks out he immediately says, "What am I going to leave out?" or "What is relevant?", he will use this particular type of questioning and analysis all the time. In fact, he can use it in other areas, such as social studies because one can look at a society as a "system" and ask what are the forces that are interacting within this system to produce change. This is no different from the scientist looking at a system and asking what are the evidences of interaction among the objects of this system.

When we introduce a model, let's just do it once in the primary or first division, and then come back to it again somewhere in the second division. When we do return to it, the child is roughly three years older. He has far more skills, mathematical ability, ability in his precision of observation, ability to infer and to predict, and to test situations, so when you return to an area it is at a completely different conceptual level.

This is the kind of approach embodied in the program which Educational Services Incorporated is developing for the elementary school. It isn't that E.S.I. doesn't have a structure. It doesn't have a structure which says we are going to teach Evolution every year, or Structure of Matter every year. It does have a certain structure when one looks at the overall units being developed. So it is with the other elementary science programs.

At the moment there are three schools of thought regarding elementary science. There is a process approach where one looks at the processes and then at the science. There is a conceptual approach where one looks at the concepts and then builds in some processes. Thirdly, we find an approach which takes a unit, sequences the processes and sequences the discrepant events in a logical pattern.

Summary

Let me summarize briefly by saying that thinking is an active process. Pupils begin with observation of a discrepant event which takes time for them to assimilate, accommodate and equilibrate. They must go through the entire process of learning if this is to take place. I think if John Dewey were alive today and looked at the new programs emerging in Science Education, he would be a very happy man. As I read Dewey, he wasn't *all* process. What he was saying was that we must carefully sequence activities. You will never have learning unless the youngsters are *engaged* in the pursuit of knowledge. The pursuit of knowledge is the pursuit of equilibrium.

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EVALUATION OF A CURRICULUM FOR ELEMENTARY SCIENCE EDUCATION

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ELEMENTARY science education is coming of age. As a comparatively recent arrival in the elementary school curriculum, it has captured the imagination and attention of some of the outstanding professional science organizations in the country. Scientists and educators are pooling their knowledges and talents to create new programs of elementary science education, as well as new books and teaching materials. Departments of education in the colleges and universities are cooperating by inaugurating and updating methods courses for teaching elementary science.

In 1965 the Department of Education of Hunter College introduced a methods course in elementary science education which is undergoing continuous evaluation and revision. This course includes methods and materials appropriate for classes from the kindergarten to the sixth grade.

In structuring such a course, several basic questions were considered:

1. What shall be the objective of a course in elementary science?
2. What shall be the content of such a course?
3. How shall this course be evaluated?

This paper is concerned primarily with evaluation and its implication for objectives and content. The purpose of this study was to obtain feedback data of value in evaluating and revising this course in Elementary Science Education.

Description of the Course

"Science Education for Elementary School Teacher" is a one-semester, three-hour required course, designed to acquaint students of education with the content and objectives of the elementary school curriculum and with the methods, materials and resources appropriate for teaching of science to elementary school children. Since the majority of the students in the course will teach in New York City, the special nature and problems of urban education is emphasized as well as the syllabi developed by the New York Board of Education.

The course includes laboratory work, discussion, practice teaching experiences enriched with films, field work, field observations of elementary school classes and visits to science resource areas.

Populations

Evaluative data were obtained by questionnaire from samplings of three populations. There were:

a. beginning elementary school teachers who had taken the methods course on the Bronx Campus of Hunter College either in 1965 or 1966, and were currently teaching in an elementary school located in the Bronx.

b. student teachers from the Bronx Campus assigned to Bronx elementary

schools who completed the practice teaching course in the Spring 1967 semester, and who had taken the methods course the previous semester.

c. students who completed the science methods course on the Bronx Campus in June 1967 in preparation for student teaching.

Procedure

The questionnaires for teachers and student teachers were essentially the same. Background information was sought including how often the respondent taught science, and the syllabus being used. Nine common problems encountered in teaching science were listed and the respondents were asked to rank them in order by placing (1) next to the one which was the greatest problem, (2) the next greatest problem and so forth.

They also evaluated by rank order the value for the beginning teacher in science of twelve method course experiences. In addition, they also rated these same 12 course experience items on the basis of which they thought would be most helpful and needed by the beginning teacher.

Finally, in an open ended question they were given an opportunity to make suggestions and recommendations for course content activities which they thought would make the course more functional and useful to the beginning teacher in science.

Teacher questionnaires were distributed through school principals and returned in self-addressed envelopes. Student teacher questionnaires were distributed by college supervisors and returned in self-addressed envelopes. Method student questionnaires were administered and collected by the teachers of the methods courses.

Findings

Elementary School Teacher

Anonymously completed questionnaires were returned by fifty teachers in twenty-six elementary and six junior high schools. Among the respondents were forty-four women and six men. Two-thirds had completed their first year of teaching, and one-third, their second year in the elementary schools. All grade levels were represented from kindergarten to grade eight. The largest number were teaching the first grade, followed by the kindergarten, and grade two.

An average of seventy-five minutes per week was devoted to teaching science with a range from 20 to 180 minutes per week. Only two teachers indicated that they did not teach science. The greatest number of teachers taught science 90 minutes per week. Practically all of them used the New York City Syllabi.[1]

Student Teachers

Anonymously completed questionnaires were returned by seventy-four student teachers who had served in twenty-one different elementary schools in the Bronx.

They had been assigned to all grades from kindergarten to the sixth grades. One through four were most common. Two-thirds of the student teachers taught daily and the remainder, no less than twice a week. The average number of science lessons taught by these student teachers during the entire term was four. Only four reported no science lessons, and one, a science lesson every week. The New York City syllabus was the overwhelming choice of student teachers.

Problems of Science Teachers

Beginning teachers and student teachers were asked to indicate their problems in teaching science by placing (1) in front of the item which represented their greatest problem, (2) in front of the next greatest problem, and so forth. The rank order of these items based on average ratings were as follows:

[1] Board of Education of City of New York. *Science Grades K-6* Curriculum Bulletins, No. 2 a–g, 1961.

TABLE I

RANK ORDER RATINGS OF TEACHERS AND STUDENT TEACHERS ON PROBLEMS IN SCIENCE TEACHING

Item	Average Rank Order: Teacher	Average Rank Order: Student Teacher
(a) Science equipment	1	2
(b) Textbook	3	3
(c) Reference books for pupils	2	1
(d) Teacher reference books	5	6
(e) Science classroom	4	4
(f) Supervision	8	7
(g) Background in science	6	5
(h) Familiarity with science equipment	7	8
(i) Ability to use and demonstrate equipment	9	9

There was remarkable agreement between beginning teachers and student teachers with respect to the items constituting their problems in teaching science. The degree of agreement, expressed statistically as the rank order coefficient of correlation, was .96.

The source of greatest problems for the beginning teachers was the physical and mechanical requirements for teaching science—equipment, textbooks, reference books, and a science classroom. These are largely a matter of school organization over which classroom teachers have very limited control. Nevertheless, they suggest to school administrators an area which needs more attention and improvement. These problems may be encountered by all beginners in "learning the ropes." However, they may be so formidable as to limit the opportunity of the teacher and dampen her enthusiasm for science teaching. The use of science coordinator and the appointment of laboratory assistants, particularly in some of the intermediate schools, may provide the supports to aid the beginner.

It must be remembered that modern science teaching requires more than a book, a blackboard, and a piece of chalk.

Course Content

The content of the methods course was also evaluated by beginning teachers and student teachers. They rated their course experience in rank order, by placing (1) in front of the most valuable, (2) along side the next most valuable.

The average rank order ratings are summarized in Table II.

For the beginning teacher, "science content" was most valuable, and then "syllabi," "teaching techniques," and "science teaching concepts." They fèlt that content, followed by methodology were the most valuable contributions made by the methods course.

Student teachers agreed that content and methodology were the most valuable contribution made by the course. However, they placed "doing experiments" first, "preparing lesson plans," second, "teaching techniques," third, and "science content," fourth. Methods appeared to be more important than content to them.

Both felt that peer teaching and making charts, models and apparatus as least valuable experiences. The rank order coefficient of correlation was .57 which indicates limited agreement in ratings. The emphasis of the teachers on science content may be regarded as an aspect of their preoccupation with the logistics of teaching, content being a basic tool for the beginner.

TABLE II

RANK ORDER RATINGS OF METHODS COURSE CONTENT BY BEGINNING TEACHERS AND STUDENT TEACHERS IN SCIENCE

Course Experience	Average Rank Order: Teacher	Average Rank Order: Student Teacher
(a) Science content	1	4
(b) Handling apparatus	6	7
(c) Doing experiments	8	1
(d) Making charts, models	10	11
(e) Teaching before peers	11	10
(f) Observing other students teach	12	12
(g) Observing a teacher	5	9
(h) Preparing lesson plans	7	2
(i) Become familiar with tests & references	9	8
(j) Become familiar with syllabi	2	5
(k) Teaching techniques	3	3
(l) Science teaching concepts	4	6

Student teachers do not have the responsibility of providing the materials required for science teaching. They are in a position where they must demonstrate teaching skills. This may explain their emphasis on methodology.

The greatest difference between teachers and student teachers was the value they saw in "doing experiments". Student teachers ranked this first; teachers ranked it eighth. Possibly this is a measure of the degree to which these two groups engage in experiments. For the teacher, logistics is the major problems and this may deter the teacher from setting up and carrying out science experiments.

Needs for Teaching Science

Teachers, student teachers, and methods students evaluated the methods course in terms of what they believed were the needs of science teachers.

The rank order ratings given to the methods course content are summarized in Table III.

Teachers felt the greatest needs for beginners was "science content," followed by "teaching techniques," "science teaching concepts," and "doing experiments," that is, content and then methods.

Student teachers ranked, "teaching techniques" first, "science content," second, "syllabi," third, and "text and reference books," fourth. Method was taught to be more important than content.

In general, there was considerable agreement among teachers and student teachers regarding the needs of science teachers as expressed by the rank order coefficient of correlation of .85.

However, students who had just completed the methods course placed "peer teaching" experiences at the top of the list followed by "science content" and "teaching techniques." The need which they emphasized were teaching experiences and techniques and also content.

There was no agreement of students either with teacher or student teachers as to the needs of science teachers; the rank order coefficients of correlation were —.11 and +.05 respectively.

One may wonder why methods students place "peer teaching" at the top of their list of needs and both teachers and student teachers put this same item at the bottom. Students in a methods course have had little or no experience in a school classroom with children in a real situation. To these students, teaching before or with peers is the first step towards becoming a teacher and represents their own needs. Teachers and student teachers are beyond this phase in their training. They are confronted with the real situation and are concerned with the needs of teachers in the actual classroom situation.

TABLE III

Rank Order Ratings by Teachers, Student Teachers and Methods Students of Course Content According to Needs of Science Teachers

Course Content	Rank Order Ratings		
	Teachers	Student Teachers	Students
(a) Science content	1	2	3
(b) Handling apparatus	8	8	8.5
(c) Doing experiments	4	5	5
(d) Making apparatus, etc.	10	10	12
(e) Peer teaching	12	11	1
(f) Observing peers teach	11	12	2
(g) Observing teachers	7	9	6
(h) Lesson plans	9	6	7
(i) Texts and reference books	6	4	11
(j) Syllabi	5	3	10
(k) Teaching Techniques	2	1	4
(l) Science teaching concepts	3	7	8.5

Suggestions and Recommendations

The last item of the questionnaire invited suggestions and recommendations for making the science methods course more functional and useful. The greatest number of responses were made by the teachers and the fewest by the methods students.

Nine out of ten teachers offered suggestions and the majority of these felt that the major emphasis in the course should be on method and not content. The specific activities mentioned were doing experiments, handling equipment, preparing lesson plans and opportunities to teach. Several teachers recommended that the methods course and practice teaching should be taken concurrently. A few expressed the need for developing special procedures and materials for teaching educationally and socioeconomically disadvantaged children.

More than half the student teachers offered suggestions. They emphasized the need for more opportunities to teach and for observing teaching. The stress they felt should be on method rather than content.

Relatively few of the methods students suggested changes in the course. Their recommendations included more time for visits to schools not only to observe teaching, but also to teach children. They also stressed method rather than content.

DISCUSSION

The questionnaire responses indicate possible guide lines in planning a course of study for elementary science.

1. *Logistics*

The problems of logistics in science teaching for the beginning teacher cannot be dismissed as a problem confronting all teachers. Organizing the tools of science teaching is no small task and can have disastrous consequence on teacher morale and initiative. To better prepare prospective teachers to meet this problem inherent in science teaching, the visits to local schools to observe a lesson in science being taught should be extended to include a study of the science equipment, textbooks and reference books and classroom organization for science teaching. A "behind the scenes" conference with the science teachers, supervisors and laboratory assistant for the specific purpose of finding out how these basic problems are handled might be arranged.

In addition, methods students should be introduced to catalogues of scientific supply houses and publishers, source books, and other pertinent references. Students should also be made aware of local resources including easily available and inexpensive household materials.

It is not beyond the realm of possibility for school districts, the Board of Education, and the colleges themselves to establish centers to which beginning teachers could turn for help in these matters.

Methods students generally feel that their background in science either completely disqualifies them to teach science or places limitations upon their effectiveness as science teachers. They are concerned with method versus content, and tend to think about these two facets of teaching as separate and distinct entities. Teachers stress content, student teachers want more teaching techniques, and methods students ask for more teaching experiences.

2. *Role of Teacher*

These reactions suggest another area in which methods courses can make a significant contribution in preparing students; that is, a role of the teacher in modern science education. Implicit in the suggestions of the teachers and student teachers, is the assumption that the teacher is the center of he learning process. The teacher is seen in her traditional role as a "renaissance man," the fountainhead of all wisdom and information. She tells the pupils what she wants them to learn and how to learn the material. The class usually watches her do an experiment; she tells them what to look for and what to see. She performs before a captive audience in which pupils are passive spectators. Feedback is almost always in the form of either oral or written "right answers" to highly structured teacher

questions. In this setting, the teacher must indeed be a walking encyclopedia, a very frightening concept to both teacher and pupils.

3. *Trends in Science Teaching*

The newer programs in science education are attempting to reverse the traditional pupil-teacher relationship. For example, the Science Curriculum Improvement Study [2] is developing a program which provides children with first hand experiences with scientific phenomena. Pupils are allowed to discover rather than cover science. The teacher is no longer the dominant figure, and the only source of information. Her role is to create an environment that invites and supports curiosity, investigation and inquiry. In this program, teaching is listening to the children as they talk to one another and not to the teacher. The teacher guides but does not dominate. The strategy is to promote learning by promoting interaction among children.

Students in methods courses should become familiar with the new curricula and new materials being developed. In elementary science education some of the new curricula are: Elementary Science Study—ESS; Minnesota Mathematics and Science Teaching Project—MINNEMAST; Science Curriculum Improvement Study—SCIS; Study of a Quantitative Approach in Elementary School Science—SWARZ; the California Elementary Science Project. There are in addition, Concepts in Science—CIS; Kenneth and Schmidt—An Approach to Reading Through Science; Tannenbaum and Stillman's—Experiences in Science as well as state and city departments of education that have developed new curricula such as the New York State and New York City Elementary Science Syllabi.

Students should also be aware of the efforts being made to evaluate several elementary science syllabi and materials to determine their suitability for use with urban disadvantaged children in urban areas.[3]

SUMMARY AND CONCLUSIONS

The curriculum of a new course in elementary school science methods introduced at Hunter College was evaluated. Feedback data obtained by questionnaires from samplings of newly appointed elementary school teachers, student teachers and students who had completed the course on the Bronx Campus of Hunter College. Teachers and student teachers listed in rank order the problems encountered in teaching science and also evaluated in terms of their value for the beginning teacher, the content of the methods course they completed. All three groups, then rated the methods course content as to what they thought was most useful and helpful for the beginning teacher in science.

The teacher and student teacher were in almost complete agreement that the major problem for the beginning teacher in science was logistics; obtaining and organizing the basic materials of instruction such as apparatus, text and reference books and having the proper classroom for science teaching.

The most valuable areas in the methods course for the beginning teacher was science content followed by methodology. Student teachers placed greatest emphasis on methodology. For example, in the list of twelve items of methods course content, teachers ranked "doing experiments" eighth whereas student teachers ranked it first. This assessment tended to reflect the responsibility of the respondents to the teaching situation.

In assessing the contribution of course content to the needs of elementary science education, teachers again stressed content and student teachers methods. Nevertheless, there was substantial agreement among

[2] Kageyama, Christina, "From Foreground to Background: The Changing Role of the Teacher," *Newsletter,* Science Curriculum Improvement Study, No. 9, Winter 1967, 2–4.

[3] M. G. Giddings, *Proposal For a Pilot Study to Test Experimentally Some of the "New" Curriculum Materials in Elementary Science in the Public Schools of New York City.* Center For Urban Education, (mimeographed).

them generally; the point of greatest disagreement was with respect to "science teaching concepts" which the teachers ranked third and the student teachers seventh. The methods students saw needs for "peer teaching" experiences as most needed which the other two groups placed at the bottom of the need list.

The feedback data emphasized the need for focusing on at least two areas of the methods course, logistics and the role of the teacher in the light of the new curricula and new materials being developed and being tested.

Finally, this study also suggested the need for continuous curriculum appraisal to meet the changing needs of science teachers in the elementary schools which are undergoing some fundamental changes in course content and in methodology.

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THE DEGREE OF IMPLEMENTATION OF THE ELEMENTARY SCIENCE CURRICULUM IN NEW YORK CITY

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Do elementary teachers in New York City follow the proscribed curriculum in science?

In 1954 New York City adopted an elementary science curriculum which was very specifically defined in terms of time allotment, content, and major method. The amount of time considered necessary to implement the course of study was 110 minutes per week in the fourth grade and 125 minutes per week for fifth and sixth grades. The sequential treatment of the following seven areas through the elementary grades was proscribed: Magnetism and Electricity, the Earth in Space, Living Things, Sound and Light in Communication, Motion and Force in Transportation, Weather, and the Earth and Its Resources. The primary approach to science was to be Experimental, with the children seeing, touching, constructing, and finding out for themselves. The teachers were provided with handbooks which indicated the major concepts for each grade, and suggested activities designed to enhance mastery of these concepts.

Recent surveys by Wheeler, et al. [9], and Navarra [4] indicate a paucity of studies dealing with any aspect of elementary science education. Moreover, of this small number only a few dealt in any way with the teacher's role [3, 6, 11]. No studies were found which were concerned with ascertaining the degree of correspondence of teaching practices to curriculum requirements.

The obvious need for information in this regard prompted the present investigation of five elementary schools which were not considered atypical and were *not* designated as "special service" schools. They fulfilled one additional requirement in that there was *no* science specialist assigned to them. The 68 teachers of grades 4, 5, and 6 of the

TABLE I

HOW THE SCIENCE CURRICULUM IS TAUGHT

Manner of following curriculum

Number of Areas Taught	Very Closely and Enrich	Closely	Somewhat	Total	Per Cent
1	0	1	1	2	4
2	0	0	0	0	0
3	0	2	2	4	8
4	4	3	3	10	20
5	4	3	3	10	20
6	3	1	2	6	12
7	11	5	2	18	36
Total	22	15	13	50	100
Per Cent	44	30	26		

five schools were asked to respond anonymously to a questionnaire dealing with their science teaching. The results are based on the analysis of 50 responses, a return of 73.5 per cent.

RESULTS

The results indicate that science is not being taught as the curriculum designers specified in respect to time, content, and methods.

The amount of time spent is far below the curriculum requirements. In grade four in which the minimum specified was 110 minutes weekly the teachers spent an average of 58 minutes a week. In grades five and six in which the minimum specified was 125 minutes the teachers spent an average of 67.4 minutes. The average in all three grades combined was 64.5 minutes. Further examination of the data indicated that 87 per cent of the teachers did not spend sufficient time teaching science.

More than half of the teachers did not complete the required subject matter. Table I indicates some interesting findings with regard to areas covered and degree of conformity to curriculum: 52 per cent of the sample taught five areas or less; 48 per cent were considered as completing all areas. (Since the questionnaire was completed in early June, those finishing six of the seven areas were given the benefit of the doubt and were considered as having completed all areas.) However, of this 48 per cent, four teachers followed the curriculum only "somewhat." This reduces the percentage of those who adequately completed all areas to 40 per cent. By their own admission three out of five of the teachers indicate that they have not prepared their students for next year's science work. A close look at the Table I seems to indicate a relationship between coverage and degree of conformity to the specified curriculum, indicating that teachers who cover all areas also tend to follow the proscribed curriculum.

The methods used to achieve the objectives and the major method so used are indicated on Table II. It is obvious that the teachers used a variety of methods in teaching science. It is notable that less than half used Experimentation as their major method although the handbooks call specifically for this method.

The teachers were asked to indicate the factors which limited their science teaching. The following factors and percentage who checked each follow: Lack of equipment, 46 per cent; lack of time, 44 per cent; lack of storage space, 34 per cent; lack of teacher

TABLE II

METHODS USED IN TEACHING SCIENCE

Method	Per Cent Using	Per Cent Using as Major Method
Television	42	12
Radio	12	0
Discussion	100	22
Experiments	88	46
Reports	92	2
Films	54	0
Textbook	72	12
	(No major method)	6

background, 30 per cent; lack of student background, 25 per cent; "nothing," 6 per cent.

The teachers were also asked if they believed science specialists were necessary to carry out the science curriculum in the elementary schools and responded as follows: Yes 74 per cent, No 16 per cent and Undecided 10 per cent.

DISCUSSION

It is apparent that there is a large divergence between what the curriculum planners call for, and what teachers actually do in teaching science in New York City schools. The teachers deviated sharply from the minimum standard in time allotment, areas covered and method used.

In trying to determine what the responsible factors were for this poor showing it is interesting to note the response to two questions. Only 30 per cent indicate teacher background as a possible factor in limiting their science teaching, but in a related question on the need for science specialists to carry out the science curriculum, 74 per cent agree that such specialized help is necessary. The latter question does not contain a blaming element which probably accounts for the higher percentage of respondents choosing it, and comes closer to what is probably the heart of the difficulty, namely, teacher feelings of inadequacy. It would seem evident that if the teachers were strongly motivated and had strong positive feelings about their adequacy in science, they could overcome such expressed difficulties as lack of time, equipment, storage space, etc. One suspects that such factors are but poor excuses designed to cover up the teacher's personal inadequacy in knowledge and attitude.

One major obvious solution to this difficulty would seem to be a course to improve the teacher's attitude and knowledge about science. Washton, in his study on the effects of teachers taking a science methods course, gives strong support to this contention [11]. It is a well-known psychological truism that there is a high degree of relationship between mastery of subject matter and favorable attitude. Such obstacles as those cited very often disappear when something is favorably viewed and desired.

Curriculum designers in order to ensure the success of their plans must establish procedures which go beyond the usual methods of giving inservice courses, T.V. courses, passing out handbooks, or lists of detailed instruction. They must obtain the cooperation and consent of those who are responsible for implementing the changes by overcoming their fears and biases and specifically indicating the positive benefits for students and teacher. The procedure of involving interested personnel in "action research" would seem of value.

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THE IMPACT OF EXPERIMENTAL PROGRAMS ON ELEMENTARY SCHOOL SCIENCE

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Elementary school personnel are experiencing an unusual situation today concerning curricular innovations. While a few years ago curriculum changes were developed primarily by teachers themselves, the curricular possibilities of the 1960's have evolved through the cooperative work of academic experts and highly qualified, select classroom teachers. It is general knowledge that elementary school science and mathematics have been experimented with more extensively than have other curricular areas in the elementary school. For the most part elementary science and mathematics curricula of this decade have been written, taught in sample classrooms, tested, re-written, taught again, and often revised again. Furthermore, the composition of the several groups working in the various writing conferences has been national in scope as opposed to either regional or local.

CAUSES FOR NEW PROGRAMS

The Influence of High School Revisions

To understand more fully the implications of the experimental curricula, it is necessary to examine some of the causes for the emergence of the trial programs. One of the more prominent stimulators of experimental elementary curricula was the wide acceptance of science programs developed since 1955 for the high school age group. These can no longer be considered experimental today. The Biological Science Curriculum Study (BSCS), the Physical Science Study Committee (PSSC), the School Mathematics Study Group (SMSG), to mention only a few, are well known examples of high school curricular developments. Innovators at the secondary school level became more and more concerned that students entering high school should have a better and a different type of background in science and mathematics than students had had previously. It was felt that the lower school preparation should not revolve around added quantity of science or mathematics per se, but it should reflect a deeper insight into the structure of the subject and the very method of inquiry unique to that subject. These innovators, who represented academic specialties in the sciences and education, began to investigate means of revising the elementary school programs. As a result several elementary curricular experiments grew in downward trend, while others began with kindergarten and grew upward.

Explosion of Knowledge

A second cause for the experimental work in elementary science and mathematics was the veritable explosion of knowledge resulting from, and contributing to, the scientific era we are experiencing. The older emphasis on the accumulation of factual knowledge for its own sake could no longer remain valid because of the plethora of this knowledge and the rapidity with which factual knowledge was outdated. It became evident that quantity alone would not do, but that a qualitative revision of the early work in science and mathematics was required. Unlike the weeding out process of the 1890–1910 era revision in elementary arithmetic in which complex and difficult "problems" were discarded, this present revolution in science and mathematics emphasized a shifting of focus away from social utility toward two closely related objectives: a comprehensive investigation of major ideas called the structure of discipline; and the ability to act as a scientist acts called the process of inquiry of the discipline.

New Advances in Learning Theory

Closely related to these were the concerns of cognitive psychologists [1] for how one learned best and retained best those things learned. Early indications from psychological studies emphasized the position taken by the experimental curriculum builders: one retains learning best if it follows a pattern—but this pattern or structure is unique to the subject matter and to the learners way of structuring the subject. Another psychological premise underscored the manner in which persons learned—the process of involvement. Interestingly enough, both of these ideas have been part of the stock-in-trade of highly competent teachers. While most teachers have tended to operate on an intuitive plane concerning either or both of these ideas, it has taken the learning psychologists to initiate the placement of the ideas into the more formal, logical pattern and thus enabling the educators to examine and implement these ideas more fully.

Speeding Up the "Grassroots" Process

A fourth factor in assessing the advent in elementary curricular innovations, oddly enough, was the very procedure used in developing curricular programs prior to the experiments of the 1960's. This writer recognizes the need to fully explore the pros and cons of teacher involvement in curriculum building, and admits a strong bias toward teacher involvement. Yet this article is neither the time nor the place for such an extended discussion. The point to be made here, however, is that despite the positive aspects inherent in a philosophy of grassroots curriculum development, the factor of social lag had become extremely significant. According to many persons involved with the rapid transformation of knowledge and ways of knowing, there was not time to permit a thorough realignment and education of all personnel in terms of content, psychology, educational methodology for individuals to become experts in each and every speciality. It followed that these tasks, then, could not remain the sole responsibility of school personnel, who may be competent in one specialty only—methodology, with secondary competencies in other areas such as content. More and more the fact had become evident that what was needed was a broadly based team approach with several specialists brought together to share solutions to common problems. The Woods Hole Conference [2] held in 1959 was a good example of this approach to problem solving in curricular development.

However important the grassroots program was concerning curriculum development, it fostered a diversity that could be typified as unevenness in the emergence of sound programs. Furthermore, under the guise of grassroots curriculum, many schools left the elementary science program almost entirely to the interests of the individual teacher who may have had limited resources and interests to bring to bear in solving this problem. This resulted, oftentimes, in a fragmented, factually oriented program in elementary science, and a dull, routinized, mechanical operation in mathematics, with the textbook as the sole arbitrator of both methodology and content.

The Need to Keep in Touch With Emerging Knowledge

Where curriculum committees did exist in local school systems, these were composed almost exclusively of public school personnel—teachers, administrators, consultants—who themselves were not close enough to the emerging knowledge in the several disciplines. This is not meant to castigate curriculum committees for not including the scientific specialists earlier: these scientists and academic specialists had spurned any commitment they might have had to the broader field of public education for they were committed solely to their discipline. So the situation evolved wherein the public school curriculum committees tended to rework the older content of the curriculum and to emphasize the comfortable pattern of subject matter in elementary science based

on the biological sciences for the most part, with some inclusion of the physical and earth sciences. The outcome of this situation was a heavy stress upon the acquisition of factual information.

Then, too, these same committees knew only too well the complex task faced by elementary teachers in the self-contained classroom as they implemented the many curricular areas: the subtle weaving together of experiences and concepts drawn from social studies, science and the skill involved in the language arts-mathematics spectrum into a meaningful classroom learning experiences. The elementary classroom teacher typically has focused major attention on the development of the child, and in so doing she has utilized subject matter content as a vehicle for accomplishing this goal.

As a result of concerns more immediately connected with children in the elementary classroom, a lack of close contact with emerging knowledge a point of view consistent with assisting individuals to develop through the older curricular patterns, the grassroots type of curriculum development was slow and intermittent. Communities which developed science curriculum guides tended to follow two or three basic patterns. These in turn were not too different from basic patterns established in elementary science textbooks. Segments of subject matter were apportioned out to the several grades, either in a spiral pattern or a block-and-gap pattern, or modifications of one or the other. In the more unfortunate communities, the textbook might well have constituted the elementary science curriculum, which in turn was essentially a reading program because the teachers lacked equipment, know-how, or scientific background sufficient to involve children in science activities.

Scientists Encourage Curricular Change

In the meantime, while educators were pleading with boards of education for released teacher time to do curriculum development or to get the necessary inservice education essential to update the curriculum, scientists were developing grave concerns for the outcomes of the then extant science curricula throughout the elementary and junior high schools, in keeping with the earlier concerns for secondary school science and mathematics. Knowledge was being "produced" at a rate that made "learning the facts" an impossibility. Furthermore, scientists have long felt that the end product of science knowledge was only part of the picture. Another significant factor was the ability to do science, to "science" as it were. Thus the emphasis, in the eyes of scientists, should swing toward the process of science and away from the facts. The end product of knowledge could not be eliminated nor should it—but the way in which one finds knowledge became as important as what was found, particularly for elementary age children. The impossibility of predicting what one might need to know in the future has led scientists and educators alike to view education as a life long operation, and the function of formal education to provide basic learning tools to enable the learner to continue to learn for himself.

The scientists recognized some similarities between the native curiosity of the child and the intellectual quest of the scientist, however they noted that where the scientist was sophisticated in applying his disciplined mind to assist him in pursuing problems when the going got difficult, the child tended to drop his quest when his curiosity was satisfied. It was upon this need for knowing inherent in child and scientist alike, along with the realization that the knowledge of an educated person could no longer be encyclopedic, that prompted scientists to engage in curricular ventures, first at the secondary school level, and increasingly since 1960, at the elementary school level.

Common Features in Experimental Science Programs

Numerous experimental programs in elementary school science have been developed.

These have several features in common. In the first place all programs are *experimental*. This means that they are being tested, re-written, and tested again. In some, the testing is very rigorous, and the very nature of the program is carefully controlled. It is a tribute to educational research, and particularly curriculum research, that the testing is as rigorous as it is. Educational experimentation, in some programs, is approaching an exactitude found in the physical sciences [3]. These same experiments, as with all experiments, may prove or disprove the hypothesis being tested. This must be kept in mind. The experimental programs, as they now stand are not designed as a national curriculum in elementary science or in elementary mathematics. The manner in which the experimental curricula may influence regional and local developments will be discussed in a later section of this essay.

A second feature found in common with the experimental programs is the general emphasis on the teacher as a guide and director, rather than a font of knowledge. This role, in which the teacher sets the stage for learning ("structures the situation") may be somewhat upsetting to teachers who view science and mathematics teaching as having only one correct answer. Facts are not ends in themselves. The teacher can no longer operate in a dogmatic, "sole-source" manner in which she places greatest emphasis on "telling" children about science information.

This brings about a third similarity. This is the emphasis on process or "scienceing" mentioned earlier. Subject matter is taken from different sources than one would previously have found in elementary science programs. For example, one might observe how insect larvae behaves under certain circumstances. It is not as important to learn specific facts about specific larvae as it is to learn how to observe, to collect data and to interpret these data [4].

A fourth similarity in the experimental programs is reflected in the importance given to the development of mathematical skills and understandings concurrently with the science. Heretofore, elementary science was not quantitative, only descriptive. As a result, some of the experimental science programs introduce advanced mathematical concepts and skills at a stage much earlier than typically experienced in the elementary school.

A fifth similarity between the experimental programs is the tendency to introduce more abstract content earlier into the program. The several programs are not uniform in any way as far as the content is concerned, yet the overall approach to content selection varies from the traditional apportionment of subject matter mentioned earlier. The experimental programs also vary from the use of the science unit typical in many elementary classrooms in which science is related to reading, social studies, arithmetic, written expression, and so forth. For example, one program utilizes the abstract idea that what one perceives is relative to the position of the perceiver in time and space.

A sixth similarity between the several programs is the emphasis on child activity. The child is not a passive listener, but instead he becomes an active participant. In many programs the activity tends to be open-ended, in that there is no one answer, nor is there a preconceived answer. In several of the programs there is no children's text. This removes the possibility of science remaining solely a "reading about science." Instead, the child must engage in activities under the guidance of the teacher. It is this role, that of the guide not the teller, that is often the most difficult for some teachers to assume. It causes one to reorient one's philosophy away from the direction-giving philosophy of teaching with the emphasis on teacher activity, toward the discovery on the part of the learner philosophy with the emphasis on learner involvement. A direct result of this approach is the disquieting fact that not everyone will arrive at the same answer, not at the same time, nor even in the same manner!

A seventh similarity between these ex-

perimental programs is the change in emphasis from science as a content subject to science as a "skill" subject as well. The skill in this case has been variously labeled critical thinking, problem solving, discovery approach, or even creative thinking in science. This is closely related to the sixth point particularly when it comes to the implementation of this approach within a real classroom.

Implications and Impact of Experimental Programs

The impact of the experimental elementary science programs has begun to be felt. One outcome already apparent is the sense of respect for the specialties of the various professionals whether scientist or classroom teacher. Overheard at one recent summer writing conference was the comment made by a biologist team member concerning several elementary classroom teachers also on the team. He said, "There are some excellent elementary teachers here. They are real pros and we can be proud to work with them." The mutual respect and admiration for excellence in classroom or laboratory are bound to break down barriers in communication previously evident.

Another likely impact of these programs on the elementary school will be that teachers and school administrators will need to take time to thoroughly study the programs in depth before committing themselves to a given course. Once committed, inservice education will be needed to bring teachers into contact with the unique methodology required. A different kind of science teaching will, of necessity, emerge.

A third impact of the experimental curricula, whether these ever go beyond the testing state or not, will be the influence upon elementary science textbook materials. Some textbooks are already beginning to show evidence of the concepts and methodologies similar to those developed in experimental programs. This may be due for the most part because the science educator authors have had experience in the writing conferences. And as a result, the excitement of the curriculum experiments has been great enough to have spilled over to science educators beyond the confines of the writing teams. This in itself will be a marked impact inasmuch as the particular stimulation for a new direction has been lacking for some time in elementary science curriculum development.

The involvement of team members from several disciplines has been mentioned earlier. Cognitive psychologists and classroom teachers are sharing a new relationship involving the theoretical and the practical aspects of closely related ventures. Teachers in curriculum development have a new role, which if they become competent enough in that role to earn the respect of scientists—behavioral as well as biological and physical—they will certainly elevate themselves to a new status. Part of this new role is that of a team member who knows a great deal about the practical aspects of teaching children; who is secure enough to try new ideas that may not be her own; who is also secure enough to admit her ignorance when she does not know a fact; who is intellectually alert to devise ways of utilizing the best the new has to offer. In a sense, then, the greatest impact of experimental programs may well be felt through the redefinition of the teacher's job beyond the telling or arbitrator stage, to a fully competent guide for learning.

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E.I.: PRACTICING WHAT WE PREACH

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"BE careful you don't catch on fire!"

"Why is it turning purple? It's supposed to turn blue."

"I can't imagine why it doesn't work. It worked marvelously when I tried it at the dorm last night."

Those were some of the remarks overheard in the room during a section meeting of a required elementary education course, *Science in the Elementary School,* taught at Boston University. They related to circumstances arising from an instructional methodology which might best be termed "Evaluative Involvement" or E.I. for brevity's sake.

E.I. was designed to make each student a continuously involved participant in a science experience duplicating, as nearly as possible, actual teaching conditions encountered in the average elementary classroom. The continuous involvement is either as a demonstrator or evaluator but never as merely a passive observer. Instead of *talking* about a pupil-activity program, the students themselves are as actively involved in a college learning situation as they are expected to have their own future pupils involved in an elementary school learning program. This represents an attempting to break the unrealistic pattern of leaning heavily on the use of the lecture method in college classes and then expecting students taught this way to adopt pupil-activity procedures in their own elementary school teaching.

The mechanics of this technique are simple enough to be replicated immediately in almost any college science education course. It involves no outlay for special science equipment, no organizational or curriculum changes, may be used in conjunction with any science education text or no text at all, and is adaptable to classes of any size.

The first step is to have the library put

on reserve copies of trade books and texts which illustrate science experiments and experiences. The students are then told to use the resources of the library and any other resources they wish in order to write up the procedures of 5 science experiments, one per 4 x 6 card. On each card the various elements of the experiment may be listed under such sub-headings as Purpose, Materials, Procedure, and Explanation. The areas of science involved may be left up to the student or structured by the instructor.

The students are expected to come to each section meeting with 5 new cards and *all* the material necessary to perform 2 of the experiments. They are to search in drugstores, notions counters, or supermarkets to get the necessary materials. This is the situation many, possibly most, of them will face in the typical elementary classroom. For their experiments, all the college instructor provides is a heat source such as an alcohol lamp or hot plate. All too often college students accustomed to using sophisticated science equipment in college do not find it in their school and are tempted to fall back on the "Read pages 10 to 15 and answer the question on page 16," method of science "instruction."

The section is organized into groups of 4 to 6 students per group. It is best to form these groups anew on a random basis each meeting since the students will be rating each other and it is best to minimize any possible "halo" effect created in a previous class session. Each student gets a rating sheet on which she places the name of each member of her group. The ratings sheet awards a maximum of 4 points for Ease of Presentation, 6 points for Interest of Presentation, and 10 points for Conceptual Clarity of Presentation for each experiment or demonstration.

Each student does her experiments for her group, explains it as she would encourage children to do in class or as she would do were she actually doing the experiment in an elementary classroom herself. While this is going on, the other members of the group are evaluating her on their rating sheets. After all the science experiences have been concluded, the secretary of each group totals up each person's score from all the separate rating sheets and the "winner" from each group may demonstrate or explain to the whole class what she did and give her source for it. The class instructor may also use these rating sheets as part of his own evaluation of the class members.

During the course of these group activities the instructor, instead of standing in front of the room talking at a group of students who become progressively more disinterested as the minutes trudge by, is free to go from group to group giving advice and additional help wherever needed.

All the cards are handed to the instructor at the end of each session and may be evaluated and returned at the end of the semester. At this time, each student will have performed anywhere from 15 to 30 experiments and demonstrations and will have observed and evaluated almost 100 others. Each prospective teacher will also have a file of approximately 100 science experiences, many of which she has already sucessfully accomplished. Surely this is one solid approach to giving the prospective elementary school teacher the confidence to initiate demonstrations and experimentation in her classroom and encourage her pupils to do the same.

E.I. is a true educational activity useful in strengthening the bridge connecting pedagogical theory to classroom practice.

Name	Ease (4)	Interest (6)	Concept (10)	Total
1				
2				

EVOLUTION IN BIOLOGICAL EDUCATION PRIOR TO 1960

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FROM the very beginning of biological education in America, it was clear that organic evolution was suppressed. That the teaching of evolution was historically only a trivial aspect of biological education is a conclusion which follows from an analysis of textbook content, courses of study, and curriculum committee recommendations.

In 1883, *Textbook of Zoology* was written by H. Alleyne Nicholson, but it contained not a single reference to evolution, according to a study by Hellman [1]. In 1888 Nicholson published another text which contained a cursory treatment of evolution. In the same period Dodge's [1] *Elementary Practical Biology* was published, with no reference to evolution throughout its pages.

Sedgwick and Wilson [1], co-authors of an 1890 text entitled *An Introduction to General Biology,* presented a brief discussion of evolutionary theory. Another text, *Essentials of Biology,* written by George William Hunter [1] and published in 1911 made no mention whatsoever of evolution.

According to Paul de Hart Hurd [2], the American Society of Zoologists, meeting in 1906, proposed a course of studies for high school zoology. That organization recommended that evolution be taught only suggestively, with no direct discussion of the theory.

In 1918 the Commission on the Reorganization of Secondary Education [2] set forth central ideas upon which secondary-level biology should be based. There was no mention at all of evolution.

Hellman [1] found that *Biology for High Schools,* a 1920 text by Smallwood, Reveley, and Bailey, included a section on natural selection. Improvement was seen as Bigelow and Bigelow [1] co-authored the 1928 text, *Applied Biology,* which had a complete chapter on evolution.

It was in 1925 that the famous Scopes Trial erupted in Tennessee. John Thomas Scopes was the biology teacher who violated that state's anti-evolution statute. Not only did Ginger [3] recount the electrifying clash between Clarence Darrow and William Jennings Bryan, he discussed the fact that teachers everywhere were intimidated if they attempted to teach evolution.

Caldwell and Weller [4] in 1932 determined the opinions of thirty college biologists as to what they recommended for the high school biology course. They rated human behavior, mental hygiene, and evolution as those topics which should receive least attention.

Presson [5] in 1930 and Christy [6] in 1936 analysed the content of biology textbooks and substantiated the contention that evolution was given scant space compared to topics like morphology and taxonomy. In addition, Webb and Vinal [7] analysed thirteen courses of study in 1934 and found that evolution was given only passing reference.

In 1941 Cretzinger [8] examined fifty-four biology textbooks in the 1800–1933 period and concluded that evolution was either absent or discussed briefly in most of them.

The first nationwide survey of biology teachers was discussed in a report edited by the geneticist Oscar Riddle [9] and published in 1942. Of the 3,075 biology teachers who returned questionnaires, 916 admitted avoiding or lightly considering the principle of evolution. The survey, however, did not involve the majority of schools in backward regions and parochial schools. Thus, the committee believed that "the principle of evolution is now taught in notably less than half of the high schools of the United States." [9]

In 1950, Laba and Gross [10] sent a questionnaire to 64 biology teachers of Essex County, New Jersey. Of the 29 who

responded, 21 admitted discussing evolution, but only nine treated it in detail.

According to Hurd [2], Le Master in 1952 compared twelve city and state courses of study in biology. Paleontology and evolution were not among the subjects emphasized in both groups of publications.

In November of 1959, the University of Chicago was host to the Darwin Centennial Celebration. Among the many activities was the National Conference of High School Biology Teachers. According to Mayfield [11], the sixty-three participants were chosen from 260 persons nominated by the directors of 1959 NSF summer institutes. The highly selected biology teachers for the most part had little confidence in evolution as a fact, whereas the professional biologists had strong confidence. There was general agreement in the group that inadequate knowledge, religious opposition, immaturity of students, deficient texts, etc., were among the most serious obstacles to the teaching of evolution.

With the publication of the BSCS texts and materials in the early 1960's, biologists, educators, and teachers saw the first reasonably comprehensive treatments of organic evolution. As the BSCS program spread, publishers of traditional texts were forced to call evolution by name and discuss it more fully.

Thus the time has arrived for evolution to become in biology classes what Einstein's General Theory of Relativity is in physics classes. Whatever progress occurs along these lines must reflect not only the vast effort of BSCS, but also the persistent, responsible criticisms by eminent scientists like Oscar Riddle, Julian Huxley, George Gaylord Simpson, and Hermann Muller.

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WHAT ARE THE LIMITATIONS OF SCIENCE?

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Is there a limitation to science today? This is a widely asked question. It is the type of question which stimulates many responses. An instrument can be made to measure various responses on this topic. These responses can be correlated for validity or can be used to note science misconceptions. This instrument measured five

responses which were: (1) Impossible: science is limited; (2) Possible solution with research; (3) Least possible solution with research; (4) No opinion; (5) Has been accomplished. Students were given questions in which they were to make response. The following questionnaire was developed in September 1967 in which 300 middle class white students in the eleventh and twelfth grades took part. The author found that this question developed a high level of class discussion on many of the topics and that it was interesting to the students. It is this type of open ended discussion that is needed in science education and science education research. The table below is an abstract of the questions and data used in the questionnaire.

Many science misconceptions can be detected as in the question involving reaching absolute zero where 26 per cent stated it has been accomplished. The high incidence of 50 per cent or better was reported in eight categories. These were in the selection of possible solution with research. The prevention of human error scored high on the category impossible: science is limited which had a high discussion in class. Many students find it interesting and some answered it has been accomplished. Stopping of world conflicts had a mixed reaction which showed an even distribution of selections with no one stating it has been accomplished. These percentages can be analyzed by the class which seems to get everyone involved in a high level of class discussion. This is one of the values of this type of class activity and more inventories of this type would be good for student. More science education research such as this can both benefit the teacher and the student.

SELECT ONLY ONE OF THE FOLLOWING STATEMENTS TO ANSWER THE QUESTIONNAIRE. PLACE AN *X* IN THE BLOCK WHICH YOU FEEL BEST DESCRIBES THE STATEMENT

Questionnaire:		Selection Percentages				
		#1	#2	#3	#4	#5
1. Man: Will land on the moon's surface.	1.	1	96	2	0	1
2. Man: Will be able to communicate with other forms of life.	2.	10	43	19	9	19
3. Man will conquer all disease.	3.	27	45	24	2	2
4. Detection of birth defects.	4.	8	53	6	6	27
5. Artificial control of weather.	5.	16	33	12	9	30
6. Slowing down of aging process.	6.	23	22	23	12	20
7. Artificial control of life functions (Such as an artificial heart.)	7.	5	31	0	5	59
8. Total cure in mental health.	8.	24	33	29	9	5
9. Solve air pollution problem.	9.	2	72	17	4	5
10. Find cure for cancer (all types).	10.	30	64	2	3	1
11. Prevent world food shortage.	11.	12	62	14	8	4
12. Prevention of human error.	12.	68	7	14	7	4
13. Reaching absolute zero.	13.	19	20	15	20	26
14. Developing cities in the oceans.	14.	5	64	20	5	6
15. Stopping of world conflicts. (Such as wars.)	15.	24	28	35	23	0
16. Prevent drug addiction by education.	16.	16	58	16	8	2
17. Prevent birth defects.	17.	22	50	14	7	7
18. Be able to transplant most body organs to another individual.	18.	8	47	10	6	29

#1. Impossible: Science is limited.
#2. Possible solution with research.
#3. Least possible for solution with research.
#4. No opinion.
#5. Has been accomplished.

PUSHING BACK THE BOUNDARIES OF IGNORANCE

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In a real sense, education may be thought of as a process in which each individual is continually pushing back his boundaries of ignorance. This pushing back process begins at birth and ends at death. These boundaries of ignorance surround each individual continually, always. At birth the boundaries of ignorance are very close to each individual. As one grows, these boundaries are gradually pushed back. Boundaries of ignorance may well be thought of as encompassing every aspect of human growth and development—intellectual, physical, emotional, creational, spiritual, and so on.

Obviously at birth the child has a very limited awareness of the world into which it has been born. The world of the unknown is very close at hand. The known world consists of very limited experiences relating to the close-by experiences—food, emotions, physical surroundings—in which the parents, more especially the mother, are the most characteristic aspect. Very rapidly this very small world of the known grows and the boundaries of the unknown or ignorance are pushed back. First the parents, the cradle, the play-pen, the room, the house, the yard, the street, the block, the neighborhood, the school, the community, the town (or city), and so on are in turn the limited environment of the known as the child makes relatively rapid progress in pushing back his boundaries of ignorance. For each one, this process of pushing back the boundaries of ignorance, is an individual matter. No one can take over this process for anyone else.

At first the boundaries of ignorance are very close to the individual. But with growth and learning in every facet of human existence, these boundaries are gradually pushed back. Unfortunately with some individuals, the boundaries of ignorance remain very close to the individual, even throughout his life-time. Many factors determine the extent, the direction, and the rapidity in which different aspects of the environment are pushed back. These determining factors are as varied as are the individual characteristics of human beings. Limits are set by such factors as intellectual ability, emotional stability, personal desire, creative inheritance, opportunities, education, and so on. Certainly the matter of chance is one of the greatest factors setting the limits as to how far the boundaries of ignorance are pushed back.

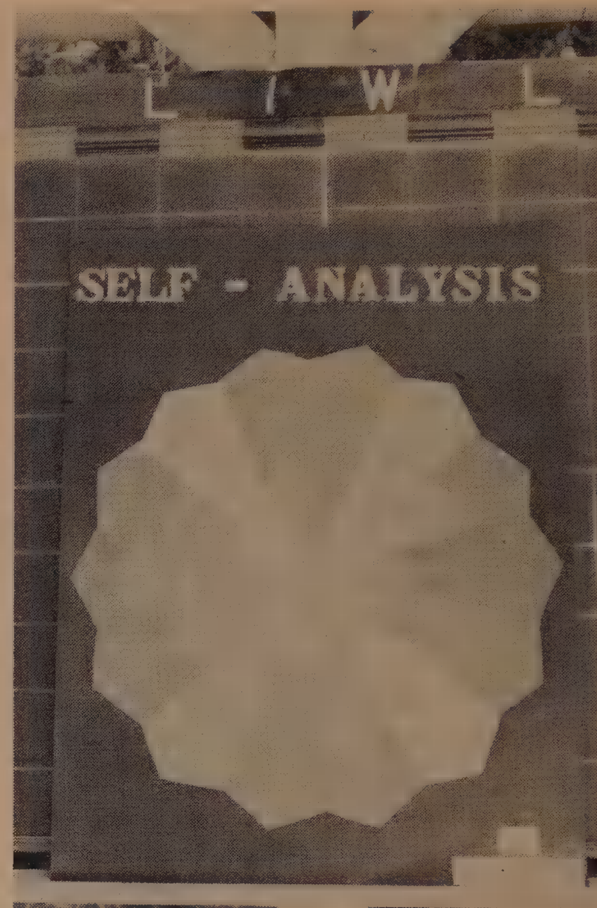
As the individuals own circle of the known enlarges, the circle of the unknown or ignorance enlarges at an even greater rate. This simply follows the well-known law in mathematics.

As we have so often reminded our students—*The More We Know, the More We Don't Know*. Too often the person who thinks he knows the most, knows the least—his boundaries of ignorance are pressing close upon him. Only the ones who have pushed the boundaries of ignorance relatively far back in some aspect of human existence can really appreciate the vastness of the area of ignorance projecting outward from his present state of knowledge and development. Only the pioneer in this facet of ignorance can truly realize how little he really knows (even if he is recognized as the world's leading authority in a particular area), of the vast realm still to be explored, investigated, and understood. Only he knows, how little man really knows and understands and actually how insignificant has been man's accomplishment in almost every aspect of human existence. So much more remains to be revealed than man now knows. Man is truly a very ignorant being. And yet so often many of man's fellow beings think or assume they

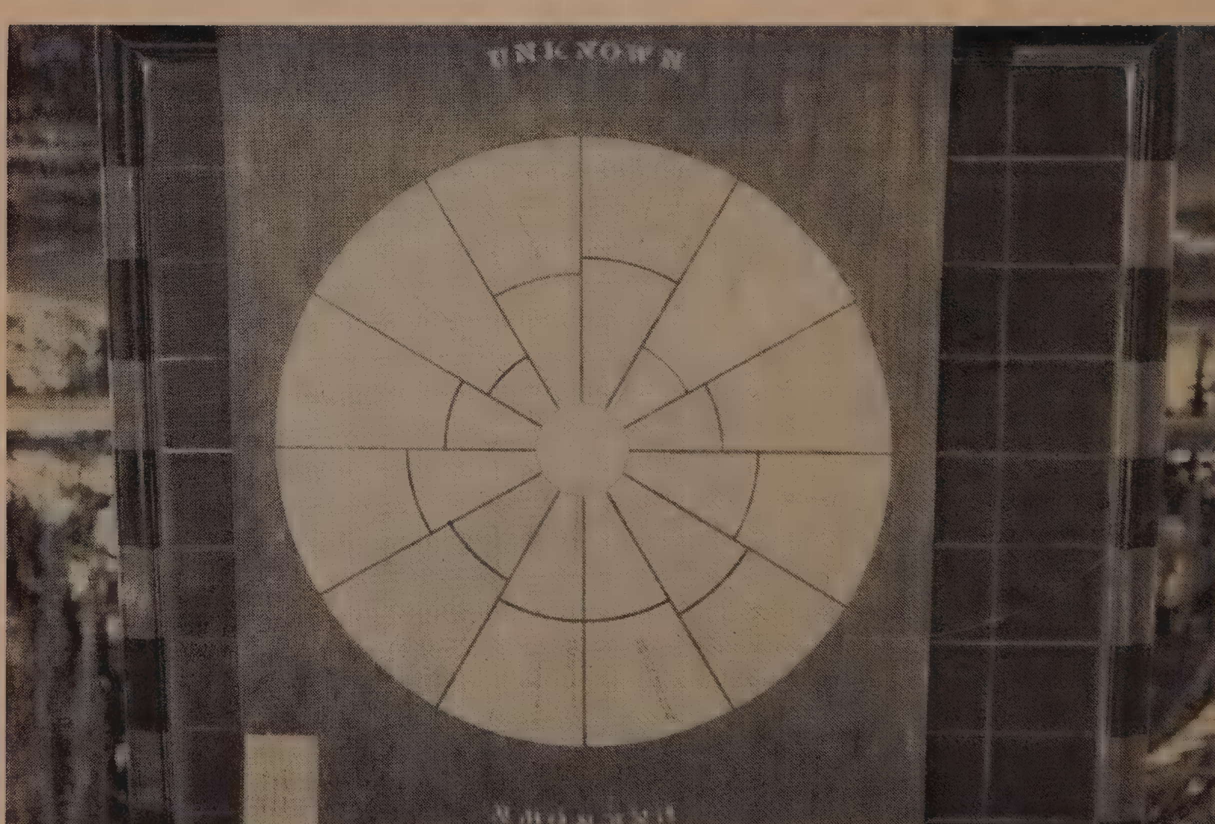
know so much, when in reality they know so little.

One facet of man's knowledge and ignorance relates to his achievement and knowledge in the various subject-matter areas. These areas are the ones in which most college students (and others) have, or think they have, some tangible knowledge or evidence. Often relative achievements in various subject-matter areas are measured by years the subject has been studied or the college credits gained. Crude as this measure is, it is more tangible than some others that possibly could be used.

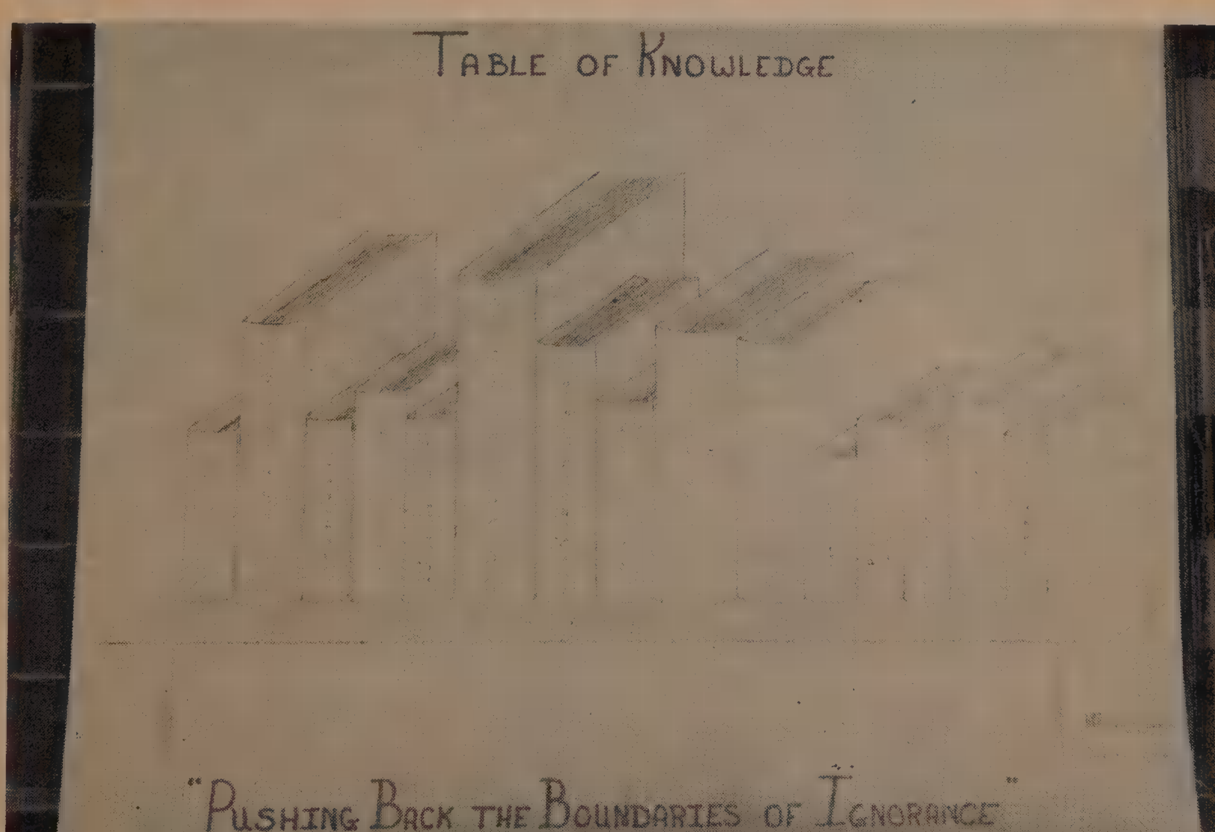
Over a period of many years but more or less infrequently at that, the writer has assigned his students the making of a chart which could well be called a Self-Analysis Chart. However for certain other reasons, the assignment has been called *Pushing Back The Boundaries of Ignorance*.

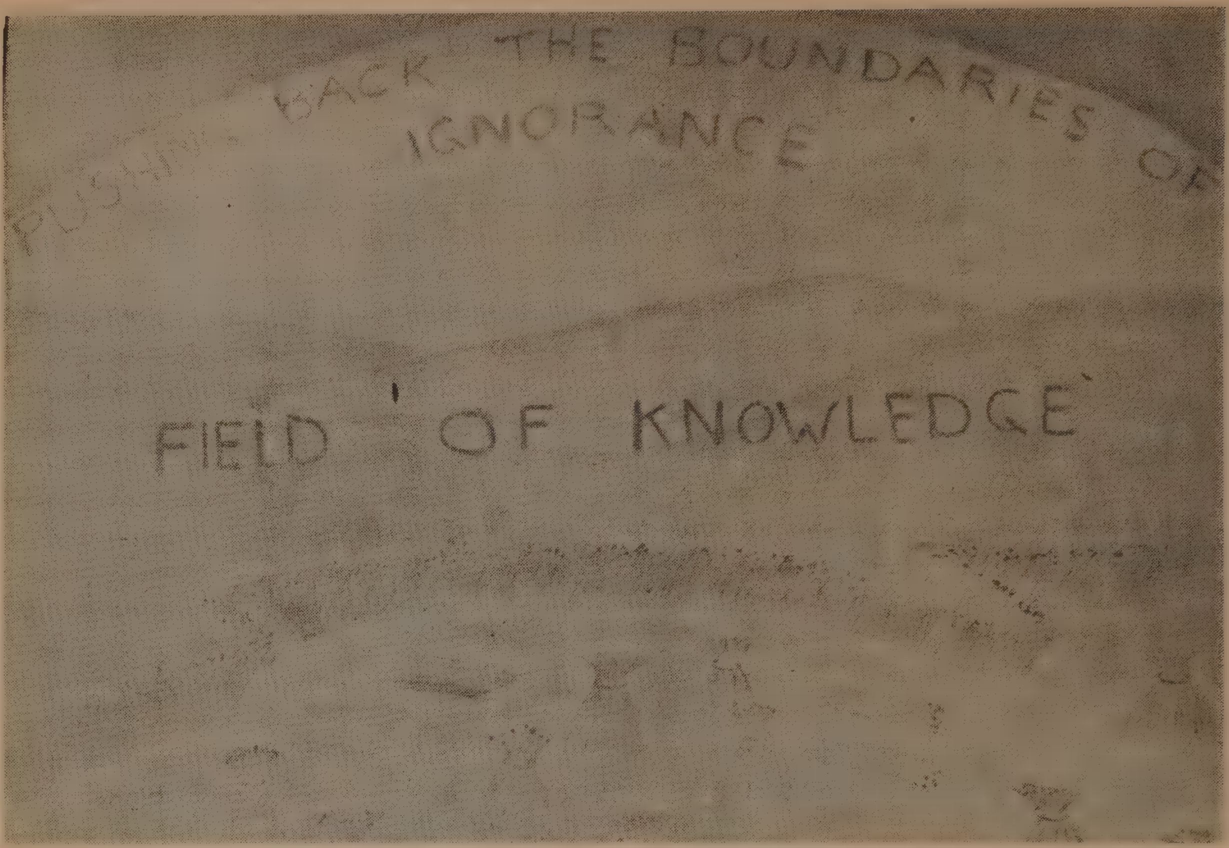


Each student had the task of evaluating relatively his knowledge in various subject-matter areas. The chart was to show how much the student thought he knew relatively about different subject-matter areas and how much more he would like to know in relation to what is presently unknown. The individual was to consider himself as the center of his individual world. Each student was perfectly free and urged to use as much creativeness and imagination as he



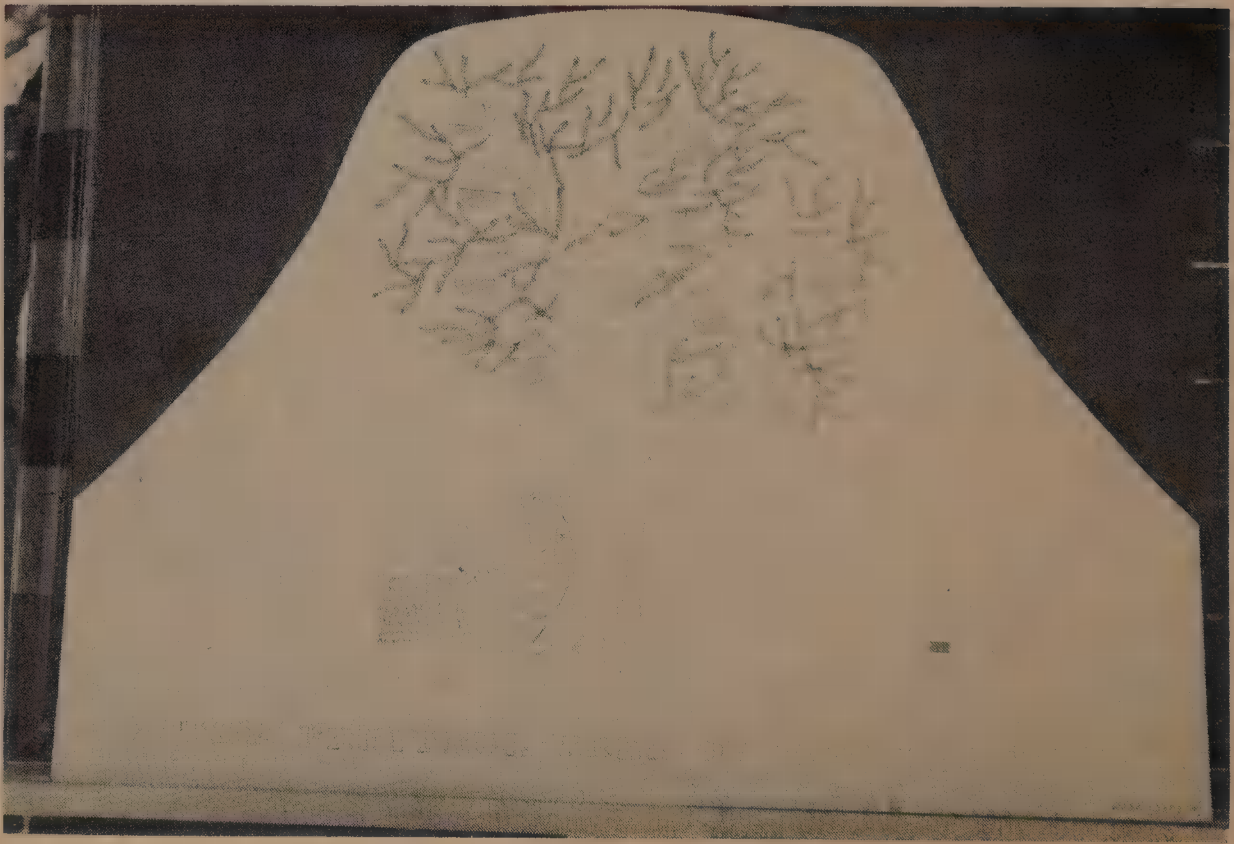
could in his self-analysis evaluation. Granted that these self-measurements were crude and often completely wrong, yet the exercise had many good features. For the first time (and in many instances, maybe the only time) in his life, the student made a self-analysis evaluation of himself—of what he thought he knew comparatively about vari-

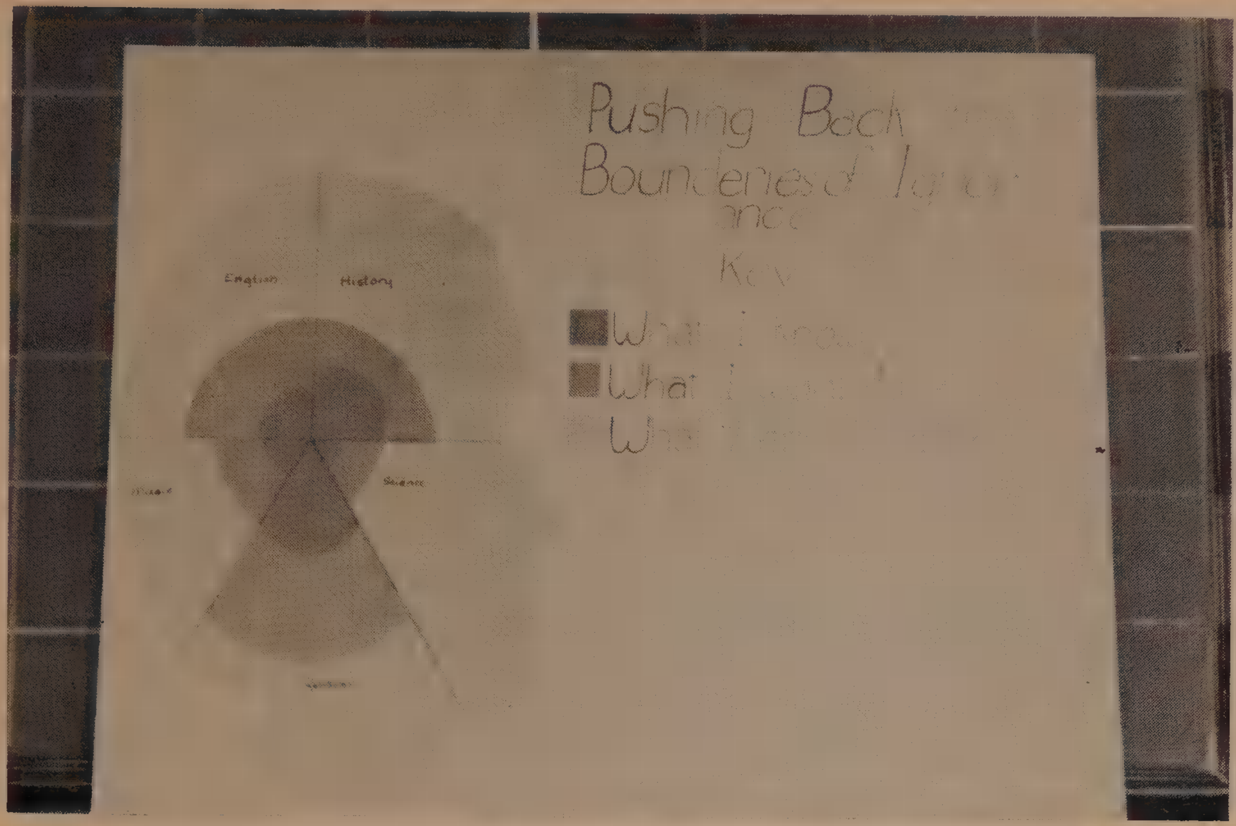




ous subject-matter areas and how much more he would like to know.

For once the student could take a good look at himself. He became more aware of the areas in which he considered himself as having at least a fair degree of knowledge and other areas in which his preparation was woefully inadequate or even lacking.





He also became aware of the Boundaries of Ignorance extending outward from himself and what vast areas of knowledge are still to be revealed.

Because of its tangibility we confined the assignments to the more concrete subject-matter fields. However, self-analysis charts could be made of other facets of man's development. Attitudes, for example, would seem to be a most promising facet.

Our experience has been that many students were quite interested and stimulated in doing the assignment. Some students spent many hours in planning and carrying out the assignment. Many students said they enjoyed this different kind of assignment. Each student could be as creative and imaginative as his talents permitted. Many charts showed a degree of creativeness and imagination far beyond the talents of the writer. Practically all charts were in attention-catching color. There were quite a few three-dimensional designs. Students with industrial arts, crafts, and wood or metal-working experience showed unusual talents in wood, metal, clay, plaster-of-paris, plastic designs.

Possibly this interesting teaching device has been published elsewhere in a magazine or a book, but we have never run across it. It is applicable in any high school or college class and would seem to be especially appropriate in art, crafts, or career classes.

The photographs in black-and-white are a poor substitute for the original most colorful charts. (The photographs were made against a blackboard background.)

CAUSAL REASONING IN SCIENCE: 1937–1964

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To anyone whose consciousness extends back a quarter-century, it seems that there has been remarkable popularization of scientific knowledge. The press reports the details of scientific inquiry into cancer, atoms, and outer space. Television, the cinema, and even works of fiction initiate us into intimate aspects of scientific experiments. Procedures for testing drugs are discussed in Congressional hearings. Little children, it would seem, are crammed with ideas about techniques for detecting underground nuclear explosions halfway around the world.

Has this popularization of science, accompanied by the greatly increased interest in science education, affected children's development of causal reasoning in science? We decided to find out by repeating part of Deutsche's study [1] of children's responses to questions commonly encountered in science curriculums.

THE DEUTSCHE STUDY

As part of her study, Deutsche presented to a large sample of children in grades 3 to 8 eleven demonstrations from the science area and asked the children to explain the demonstrations in writing. The written protocols were then categorized according to Piaget's seventeen types of causal thinking and one new category called "trickers." Deutsche reported that her coders had great difficulty in arriving at objective and reliable classification with these categories. It was necessary for them to meet and reexamine their categories and their data in order to resolve their differences. They found that only four categories occurred with appreciable frequency:

1. *Phenomenistic.* Two facts are given with no relation except spatial or temporal contiguity. "Pebble sinks to the bottom of water because it's white."
2. *Mechanical.* The explanation is by contact and transference of movement. There is no internal force. "Winds push the clouds." "Pedals make bicycles go."
3. *Logical.* Explanation is by the principle of sufficient reason. "After the jar was put over the candle, the candle burned the oxygen and there was no more gas fuel left."
4. *Dynamic.* The student sees in objects forces that are capable of explaining their activity and movements. "It smothered" (for the candle in the jar). "The Water got out of the stone's path."

Phenomenistic responses declined with age; mechanical and logical answers increased with age; and dynamic replies were not related to age. Deutsche found every type of answer over the entire age range (8–16 years) and suggested this was evidence that there are no "stages" in causal thinking.

Repetition of Deutsche's work appeared overdue and interesting for a number of reasons. First, she reported that the group testing techniques were very satisfactory. It seemed worthwhile to investigate on a wide-scale children's causal thinking. The contemporary curriculum materials are based, for the most part, on the presumption that children can use or be taught to use abstract propositions effectively. Group tests of causal thinking would examine this assumption.

Second, if experience is a determinant of children's explanations of phenomena, the current popularization of science and the innovation in science teaching should be reflected in the children's ability to identify causal relations by logical deduction.

DESIGN OF THE STUDY

The subjects were the fifth and sixth grade pupils in a suburban Delaware school in which lower and middle class families were well-represented. The children were grouped for instruction in the various curriculum areas and thus represented, in the opinion of the school faculty, four ability levels for each grade. The indices for grouping into ability sections were intelligence tests, grades, and teacher judgment.

Each section was presented with ten demonstrations during a class session in the science area, and was instructed to explain the demonstrations in written protocols. The two regular science teachers performed the experiments and collected the protocols. Care was taken to standardize the procedures, and the equipment used by each teacher was the same in every case.

The demonstrations and instructions, which were taken from the Deutsche report, follow.

1. A candle is lit, and then a jar is placed over it. The flame goes out. The children are asked, "Why does the candle go out?"
2. A penny is placed in an open box which has straps attached. The box is whirled about. The penny doesn't fall out. The children are asked, "Why doesn't the penny fall out?"
3. A rock is placed in a glass of water. The water level rises. The children are asked, "Why does the water come up higher when I put the pebble in?"
4. A wooden block is dropped on the laboratory table. A noise is heard at the contact. The children are asked, "What makes the noise when the block falls?"
5. Two colorless liquids are mixed. The resulting liquid has color. The children are asked, "What makes the water change color when I pour in some of this colorless stuff?"
6. A rubber bulb on a tube is placed so that the end of the tube is in the water. The bulb is squeezed and then released. The water rises inside the tube. The children are asked, "What makes the water go up in the tube when I let go of the bulb?"
7. A teeter-totter is placed with its fulcrum off-center. A light weight on the longer arm balances a heavier one on the shorter arm. The children are asked, "Why do I have to put a big block on one end to make the teeter-totter balance?"
8. Two liquids of different color are poured into the same container. One rises to the top while the other sinks to the bottom. The children are asked, "Why does the colored liquid separate from the colorless liquid?"
9. A paper is placed over the top of a glass full of water. The teacher inverts the glass. The paper stays over the mouth of the glass and the water does not spill out. The children are asked, "Why don't the paper and water fall out of the jar?"
10. The teacher plays a flute. He holds it so that it can be seen that as he presses different keys, different pitches are heard. The children are asked, "Why does it make different sounds when I push different keys?"

CODING PROCEDURES

Two raters, working independently, reached early agreement that many of the responses did not fit Deutsche's four selections from the Piaget group, nor did they fit any of Piaget's other thirteen categories, A number of the responses seemed to fall into a "trickery" category that Deutsche had invented to hold responses from children who thought the demonstrations were designed to foil them. Far more fell into what we called a "rote logic" category when a verbalism of a scientific principle was invoked without elaboration. It was difficult in many cases to tell whether the child was using a shortened but adequate response, or whether he was parroting a term he had heard. For example: "Centrifugal force" was sometimes given to explain item 2.

Another type of response which came in great frequency was a simple restatement of what happened, a description without an explanation. For example, "The water

didn't fall out of the jar." We labelled this new category, "statement."

Although the categories "Rote Logic" and "Statement" were added to the ones Deutsche used, it still proved difficult to achieve rater reliability. The raters were in agreement only about half the time until arbitration procedures were devised to allow them to arrive at a consensus. Table I compares the percentage of total answers in each category obtained by Deutsche and the present study.

The raters in the present study classified 32.1 per cent of the responses as "rote logic" or "statement," too large a difference to permit continuing the analysis as we had originally planned. There can be no definite comparisons because of our methodological findings. Probably the chief difference between the ratings of the two studies was that Deutsche's raters tended to assign ambiguous responses to an existing category, whereas the raters of the present study judged such answers as an attempt to fulfill the assignment either by restating the facts (Statement) or by using scientific jargon that was not fully understood in the hope that the "right combination" would be hit" (rote logic).

The subjects of the present study clearly knew a lot of scientific names for things, but used them in odd combinations suggesting that words were not backed by adequate concepts.

The haze of verbalism made it difficult to decide just what *was* going on in the children's minds. It is entirely possible that the children tended to do what they had been taught in school—produce some grammatical sentences using the words they had been taught. In other words, what may be tested in these situations is not thinking but the attempt to say something acceptable.

Support for this position is to be found in the responses to the first demonstration, the candle-in-the-jar, which is exceedingly familiar to nearly all children. In both studies a goodly percentage of the responses to that demonstration were classified "logical" (83.18 per cent in the Deutsche study, 76.7 per cent in the present study). There is no way of telling, but it is possible that the responses were frequently simple rote. The "logical" explanation for that demonstration has been repeated so many times that it conceivably has been memorized by nearly every school child. That single item accounted for one-third of the "logical" explanations recorded. Eliminating the first demonstration, the percentage of logical responses drops to 17.4 per cent in the present study.

As Deutsche had noted with her experimental procedure, responses to the demonstrations were not consistent. In the opinion of the present investigators, the differences add up to unreliability of the test. Table II gives the classification by item. The responses to the demonstration were so uniform as to be undiscriminating. The fifth item was so difficult that about one-third of the children gave no response or a

TABLE I

COMPARISON OF DEUTSCHE AND PRESENT STUDY

Category	Deutsche Study Per Cent of Total Answers at Age 12	Present Study Per Cent of Total Answers at Age 12
Phenomenistic	16.1	7.1
Dynamic	7.1	3.7
Mechanical	41.1	20.1
Logical	28.1	22.4
Trickery	0.0	2.0
Rote Logic	did not use	15.6
Statement	did not use	16.5
Unclassifiable or other classification	7.4	11.6
Other	5.1	....

TABLE II

FREQUENCY OF CATEGORY BY ITEM

Item	Dyn.	Mech.	Logic	Uncl.	Phen.	Rote	State	Trick
1	5	4	174	2	3	38	1	0
2	8	130	14	8	11	49	5	2
3	20	41	106	3	28	11	18	0
4	12	33	29	4	16	72	60	1
5	12	34	7	75	7	30	59	3
6	17	90	32	14	0	53	21	0
7	0	5	65	25	9	2	95	26
8	6	11	88	42	35	5	35	5
9	9	60	29	32	17	72	6	2
10	3	40	10	54	31	15	68	6

jumbled one that could not be classified. Item seven (teeter totter) was curious in that about ten per cent of the children thought that they were being tricked. Mechanical dominated number two, and was forty per cent of number six, although nearly one-fourth of the responses were rote. It is easy to see that the items are quite variable.

Hence, although the task of explaining the phenomenon appears similar in each question, quite different types of thinking were elicited, and most of the items had a distinct character of responses.

SUMMARY

This paper has reported an attempt to repeat with 227 fifth and sixth grade children part of an investigation of children's causal thinking reported by Deutsche in 1937. Difficulties in classifying responses to science demonstrations resulted in failure to repeat the study with precision.

A high degree of meaningless verbalism was found in the children's explanations—their knowledge of scientific terms seemed to exceed considerably their command of the concepts represented by the terms. This needs to be considered and explored further when the newer science curricula are introduced into elementary schools.

It appears that attempts to develop a methodology for determining children's ability to reason causally have to take into account the fact that children apparently resort to verbalism when confronted with an open-ended test situation, making classification of responses extremely difficult. The attempt to repeat the much-quoted Deutsche study illustrates the difficulties which can be encountered. It might be better to construct items in which jargon could not be handled easily in everyday language and, in fact, for which no special language is available.

The muddy waters described here are to be expected. Despite the critical implications of causal thinking for educators and despite the potential usefulness of Piaget's distinctions between formal and concrete reasoning, there have been surprisingly few attempts to refine empirical approaches to the important qeustions about children's ability to reason in the major curriculum areas.

Craig, Gerald S. and Bernice C. Bryan. *Science for You, Book One;* Craig, Gerald S. and Ethleen Daniel. *Science for You, Book Two;* Craig, Gerald S., Anne B. Hopman and Marguerite W. Lembach. *Science For You, Book Three;* Craig, Gerald S. and Beatrice Davis Hurley. *Science for You, Book Four;* Craig, Gerald S. and Katherine E. Hill. *Science for You, Book Five,* and Craig, Gerald S. and Mary E. Sheckles. *Science for You, Book Six.* Boston, Massachusetts: Ginn and Company, 1965. 127 P.; 159 P.; 224 P.; 287 P.; 317 P.; and 333 P. $2.76; $2.96; $3.28; $3.40; $3.52, and $3.64.

The above titles represent a revision of probably the most popular and widely used series of elementary science textbooks in use today. The series has been revised a number of times science the first editions published many years ago.

The series has been carefully graded as to readability and vocabulary difficulty. Content has been selected with the greatest of care affording at the same time desirable repetition from grade to grade yet avoiding interest-killing duplication.

Book One content: Air, Changes in Weather, How You Can Change Foods, How Your Body Grows, Where Animals Live, How Animals Move, Falling Down, Floating and Sinking, Different Sounds, Water Around You, Earth, Far from Earth, Care of Green Plants, Our Soil, Magnets and You, Electricity, and Use of Wheels.

Book Two content: Our Earth, Earth Moves in Space, Gravity of Earth, Air of Earth, Heat and Water, From Seeds to Plants, Seeds Are Moved About, Electricity by Rubbing, Space Around a Magnet, Our Sun in Space, Water of Earth, and Science Happenings.

Book Three content: Finding Out What Is Around You, Seasons in Many Places, Paths for Electricity, Living Through Many Changes, Air and You, The Moving Sun and Earth, The Changing Land of Earth, The Force of Magnetism, Plentiful Times for Living Things, Living Things Change the Land, and Satellites of Earth.

Book Four content: Molecules in the Universe, Our Planet Earth, The Atmopshere, Animals and How They Are Protected, Making Things Move, Our Solar System, Plants and How They Are Protected, Plant and Animal Communities, Magnetic and Electric Forces, How Animals Live Together, and Exploring the World of Sound.

Book Five content: Plant Life on Earth, Forces and Earth Changes, Our Moon, Earth and Sun, Inside Atoms, Theories About Electricity and Magnetism, Above Earth's Land and Water Surfaces, Light in the Universe, Living Things and Changing Climates, Chemical Changes and Atoms, Animal Life on Earth, Earth's Water Resources, and Systems in Space.

Book Six content: Ways of Thinking and Behaving, Plants and Animals of Earth Are Different, The Nature of Soil, Magnetism Everywhere, Motion in the Universe, Good Health, Adaptation of Living Things, Earth's Changing Atmosphere, A Study of Electricity, Interrelationships in the Environment, and Men Learn to Leave Earth.

Each book has at the end of the textual material a list of science words used. These science words are explained or defined.

Each book is well illustrated in attractive, pupil-appealing color illustrations. Illustrations are pertinent to the content being considered. A Teacher's Manual accompanies each book.

The authors are noted elementary science leaders. Professor Gerald S. Craig is America's best known elementary science leader. He is now Professor Emeritus of Natural Sciences, Teachers College, Columbia University.

Bernice C. Bryan is Elementary Science Consultant, Los Angeles County Schools, California.

Ethleen Daniel is Science Supervisor, Montgomery County, Maryland. Anne B. Hopman is Director of Elementary, Public Schools, Hammond, Indiana.

Marguerite W. Lembach is former Supervising Teacher, Denver Public Schools, Denver, Colorado.

Beatrice Davis Hurley is Professor of Education, New York University.

Katherine E. Hill is Professor of Education, New York University.

Mary E. Sheckles is Associate Professor of Education, University of Florida, Gainesville, Florida.

Beauchamp, Wilbur L., John C. Mayfield, and Paul DeHart Hurd. *Everyday Problems In Science; Teacher's Guidebook For Everyday Problems In Science,* and *Teacher's Edition Problem Solving In Everyday Science.* Glenview, Illinois 60025: Scott, Foreman and Company, 1963, 1964, 1966; 576 P.; 310 P. 388 P.

The above three titles are complementary books —the *Teacher's Guide Book* and the *Problem-Solving* paper-bound books to be used with the basal text *Everyday Problems in Science.* A combination of the three affords about all of the desirable content, pupil activities and experiments, and pupil exercises that a general science teacher could desire.

Everyday Problems In Science has been for many years one of the most popular and widely used general science textbooks. Continual revisions have kept it up-to-date. The authors include three of America's best known science educators—the late Wilbur L. Beauchamp and John C. Mayfield of the University of Chicago and the equally well known Dr. Paul DeHart Hurd who teaches at Stanford University. *Everyday Problems In Science* has 19 carefully selected units. Readable textual material, teaching suggestions, list of science projects, unit overviews, self-testing exercises, suggested experiments, il-

lustrations in color designed for specific learning purposes, make this one the finest general science textbooks ever published.

The Teacher's Guidebook will be of immeasurable help to the teacher. The study book is a series of carefully prepared activities emphasizing the major concepts presented in *Everyday Problems In Science.* For the teacher's benefit answers are given to each question asked or activity suggested.

BEAUCHAMP, WILBUR L., JOHN C. MAYFIELD, AND PAUL DEHART HURD. *Science Is Explaining 7; Science Is Understanding; Teacher's Guidebook For Science Is Explaining; and Teacher's Guidebook For Science Is Understanding.* Glenview, Illinois 60025: Scott, Foresman and Company. 1963, 1964, 1964, and 1965. 384 P.; 480 P.; 144 P.; and 168 P.

The above titles comprise the basal texts and the respective teacher guidebooks for the seventh and eighth grade levels of the Foresman Science Series. Each textbook has 12 science units of carefully selected, non-duplicating science content. The textbooks have the same general plan of treatment as do all of the seventh grade through junior high school level texts. Again teachers will find the teacher guidebooks very useful.

BEAUCHAMP, WILBUR L., JOHN C. MAYFIELD, AND PAUL DEHART HURD. *Teacher's Edition Science Problems 1; Teacher's Edition Science Problems 2,* and *Teacher's Edition Science Problems 3.* Glenview, Illinois 60025. 1965. 164 and 288 P.; 162 and 336 P.; and 175 and 384 P.

The above three titles comprise the Foresman Junior High School series of textbooks, most effectively used when each textbook is used in turn. Students using each of the textbooks in turn will have a very thorough knowledge of general science.

The first part of each of the above titles includes the philosophy and technique, suggestions for teaching the units, a bibliography (guide to science reading, magazines for pupils, magazines for teachers, and audio-visual aids), and materials and apparatus needed.

The pupil textbook is found in the last part of the book. Each text has ten units of carefully selected, for the most part, non-duplicating content. Organizational plan is the same as in *Everyday Problems In Science.*

MARSHALL, J. STANLEY AND WILBUR L. BEAUCHAMP. *Teacher's Guidebook for Science Is Fun 1; Teacher's Guidebook for Science Is Learning 2;* MARSHALL, J. STANLEY, HELEN J. CHALLAND, AND WILBUR L. BEAUCHAMP, *Teacher's Guide for Science Is Exploring 3;* BLOUGH, GLENN O., J. STANLEY MARSHALL, JAMES B. BAILEY, AND WILBUR L. BEAUCHAMP. *Teacher's Guidebook for Science Is Experimenting 4; Teacher's Guidebook for Science Is Discovering 5; Teacher's Guidebook for Science Is Adventuring 6.* Glenview, Illinois 60025: Scott, Foresman and Company. 1968. 96 P. and 112 P.; and 112 P. and 128 P.; 144 P. and 168 P.; 152 P. and 240 P.; 168 P. and 288 P.; 192 P. and 304 P.

The above titles comprise the books in the Scott Foresman *The Basic Science Program* for grades one through six. Each book consists of two parts: the first part has a teacher's guide division; the second part is the pupil content division. The later makes up the content found in the pupil separately hard-bound editions.

The first three Teacher Guide books division discuss: *Introduction* (Science and the Elementary School, Organization of the Book, Using Pictures and Text, The Lesson Plans, Science Publications, and Science Audio-Visual Sources); Lesson Plans on how to teach each of the five to seven units; Directory of Publishers and Suppliers; and A Typical Plan for Introducing New Words.

Guidebook for Science Is Adventuring 4 has the following divisions: Introduction (Science and the Elementary School, Organization of the Book, The Lesson Plans, and Science Publications), Lesson plans on how to teach each of the seven units; Index of Concepts, Directory of Publishers and Suppliers, Magazines for Teachers, and Science Audio-Visual Sources.

Guidebook for Science Is Discovering 5 is quite to similarly to Guidebook 4 except it adds a part in the Introduction called The Goals of Science Teaching, has detailed lesson plans for eight units but omits *Magazines for Teachers* and *Science Audio-Visual Sources.*

Guidebook for Science Is Adventuring 6 has an Introduction (Organization and Scope, How To Use This Guidebook, Science Publications, Science Audio-Visual Sources, and List of Materials), and detailed plans for teaching each of the nine units.

The Guidebook parts of each book will be extremely useful to each teacher—experienced or inexperienced—teaching that particular book. The Guidebooks offer a fine review and supplement for teachers having had an elementary science methods course. Invaluable suggestions are made for teaching and enriching each unit taught.

The texts themselves are unusually well done regardless of the criteria used for evaluation—content, vocabulary difficulty, readability, suitability and number of illustrations in color, pupil appeal in general.